2017 SOLAR ECLIPSE FIRST LOOK p. 54

Exploring the hidden nature of empty space p. 30

JUNE 2015

Astronomy®

The world's best-selling astronomy magazine

EXCLUSIVE!

Apollo 13



Jim Lovell in his own words

Triumph over tragedy p. 24



The new fight against light pollution p. 46

Apollo 8 astronauts captured this view of Earth above the Moon's stark landscape. Command module pilot Jim Lovell would later return to the Moon on Apollo 13.

AND MORE

Explore the Antares region p. 52

Stellarvue's compact refractor tested p. 62

Bob Berman on laser safety p. 11

www.Astronomy.com

BONUS ONLINE CONTENT CODE p. 4

Vol. 43 • Issue 6

CELESTRON

EXCEPTIONAL VIEWS

SUPERIOR PERFORMANCE

NO COMPROMISE

CPC AND CPC DELUXE HD

Instantly recognizable by their dual fork arm mounts, the Celestron CPC and CPC Deluxe HD have become favorites at star parties worldwide. Bring home the iconic CPC or CPC Deluxe HD and experience the views for yourself.

WITH CPC, YOU GET THE BEST OF CELESTRON'S 55 YEARS OF INNOVATION:

+ Rock-solid dual fork arm mount with precision drive base and mechanics
+ Celestron's signature Schmidt-Cassegrain optics in sizes from 8-11 inches
+ SkyAlign technology so you are aligned and ready to observe in minutes, without having to know the name or location of any star
+ NexStar+ hand control with 40,000+ object database
+ Internal GPS
+ Ready for astrophotography with All-Star Polar Alignment and optional HD Pro Wedge
+ Compatible with Celestron's latest accessories: StarSense AutoAlign for quick, self-guided alignment or SkyQ Link 2 WiFi Module for wireless control with your smartphone or tablet

STEP UP TO THE CPC DELUXE HD FOR EVEN BETTER PERFORMANCE:

+ Celestron's proprietary EdgeHD optics for pinpoint stars all the way to the edge of the field with the widest eyepieces and largest imaging sensors
+ Reengineered worm gear motor drive provides smoother tracking



CELESTRON PREMIER SELECT DEALERS

OPT Telescopes – 800.483.6287 – www.opttelescopes.com
B&H Photo – 800.947.9970 – www.bhphotovideo.com
Hands On Optics – 866.726.7371 – www.handsonoptics.com
Astronomics – 800.422.7876 – www.astronomics.com
Adorama – 800.223.2500 – www.adorama.com
High Point Scientific – 800.266.9590 – www.highpointscientific.com
Optics Planet – 800.504.5897 – www.opticsplanet.com
Focus Camera – 800.221.0828 – www.focuscamera.com
Woodland Hills – 888.427.8766 – www.telescopes.net

DISCOVER MORE AT
celestron.com

WorldMags.net

MIND. BLOWN.



5 DAYS. 50 EVENTS.

MAY 27–31, 2015 | TICKETS AT WORLDSCIENCEFESTIVAL.COM/WSF2015

Founding Benefactors	SIMONS FOUNDATION · Alfred P. Sloan Foundation · John Templeton Foundation
Major Supporters	ANN ZIFF · bezos family foundation · conEdison · Della Pietra Family Foundation · THE KAVLI PRIZE
Full Year Media Partners	SCIENTIFIC AMERICAN · WNET · THE WEEK · mental_floss · HUFFPOST SCIENCE · POPULAR SCIENCE
Festival Media Partners	abc NEWS · WNYC · ScienceNews · Astronomy · Discover · IEEE SPECTRUM · SCI

World Science Festival

Online Content Code: ASY1506
Enter this code at: **www.astronomy.com/code**
to gain access to web-exclusive content



CONTENTS

46

JUNE 2015
VOL. 43, NO. 6



NASA

ON THE COVER

During their fourth lunar orbit, Apollo 8 astronauts saw "Earthrise" from a lunar perspective.

FEATURES

24 COVER STORY
Jim Lovell: In his own words



The only person to fly to the Moon twice but never trod its surface has some amazing stories to tell. **RICHARD TALCOTT**

30
The nature of empty space
Let's talk about nothing.
BOB BERMAN

36
The Sky this Month
Venus meets Jupiter at dusk.
MARTIN RATCLIFFE AND ALISTER LING

38
StarDome and Path of the Planets
RICHARD TALCOTT; ILLUSTRATIONS BY ROEN KELLY

44
Ask Astro
Blast radius.

46
A new fight for the night
Blue LEDs may have warranted a Nobel Prize in physics, but the lights are bad news for astronomers. **ERIC BETZ**

52
Explore the Antares region
This summer, discover the spectacular area around one of the sky's brightest stars. **MICHAEL E. BAKICH; IMAGE BY TONY HALLAS**

54
First look at the 2017 total eclipse
Excitement is building for the first total solar eclipse in the U.S. in 26 years. **MICHAEL E. BAKICH**

58
To catch a shooting star
A renowned meteorite hunter turns his gaze to the sky as part of a growing network of fireball trackers. **ERIC BETZ**

62
We test Stellarvue's compact refractor
This 2.4-inch scope is so portable that you'll use it night and day.
TOM TRUSOCK

COLUMNS

For Your Consideration 10
JEFF HESTER

Strange Universe 11
BOB BERMAN

Observing Basics 14
GLENN CHAPLE

Secret Sky 18
STEPHEN JAMES O'MEARA

Astro Sketching 64
ERIKA RIX

Cosmic Imaging 66
ADAM BLOCK

QUANTUM GRAVITY

Snapshot 9
Astro News 12

IN EVERY ISSUE

From the Editor 6
Letters 11, 14, 66
Web Talk 22
New Products 68
Advertiser Index 71
Reader Gallery 72
Breakthrough 74

Visit **Astronomy.com/toc** for bonus material — it's exclusive to *Astronomy* magazine subscribers.

Astronomy (ISSN 0091-6358, USPS 531-350) is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Periodicals postage paid at Waukesha, WI, and additional offices. POSTMASTER: Send address changes to *Astronomy*, 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Canada Publication Mail Agreement #40010760.

ONLINE FAVORITES >>

Go to **www.Astronomy.com** for info on the biggest news and observing events, stunning photos, informative videos, and more.



News
The latest updates from the science and hobby



Astronomy 101
Basic science concepts explained



Reader Photo Gallery
Share your astroimaging efforts



50 Greatest Mysteries
Explore the biggest cosmic questions

WorldMags.net

ORION®

CELEBRATING 40 YEARS

EVERYTHING FOR THE AMATEUR ASTRONOMER

FREE SHIPPING on orders of $250 or more — INSTALLMENT BILLING on orders of $350 or more
See website for details.

NEW PRODUCT 2015



Orion® 1.25" Dark Frame Imaging Filter
#5451 **$29.99**



Orion® 8-Slot 1.25" Filter Slider
#5064 **$149.99**



Orion® 6-Slot 2" Filter Slider
#5065 **$149.99**



Orion® 1.25" Premium 20-Piece Color Planetary Filter Set
#5453 **$249.99**



Orion® 1.25" Specialized 3-Piece Planetary Imaging Filter Set
#5452 **$399.99**



Orion® ED80T CF Triplet Apochromatic Refractor Telescope
#9534 **$926.99**



Orion® XT6 Classic Dobsonian Telescope & Beginner Barlow Kit
#27193 **$360.49**

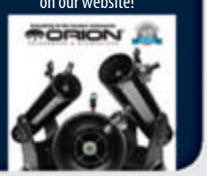


Orion® StarShoot™ AutoGuider Pro Mono Camera
#52031 **$391.39**



Orion® GoScope™ II 70mm Travel Telescope Moon Kit
#10034 **$82.39**

Shopping has never been easier.
To learn more about our products and see a larger assortment, check out the digital eCatalogs on our website!





Orion® SpaceProbe™ 130ST Equatorial Reflector
#9007 **$308.99**



Orion® Awesome AutoGuider Refractor Telescope Package
#24770 **$411.99**



Orion® Planetary Observing Guide Kit
#25703 **$49.99**



Deluxe upgrade of our popular XT8 Classic

Orion® SkyQuest™ XT8 PLUS Dobsonian
#8974 **$514.99**

WE ALSO SUGGEST

Orion® 1.25" 13% Transmission Moon Filter
#5662 **$19.99**

Orion® Padded Telescope Case
#15174 **$97.84**

Orion® MoonMap 260
#51919 **$12.99**



Orion® Atlas™ EQ-G Computerized GoTo Mount
#10010 **$1,999.99**



Orion® SteadyPix Universal Smartphone Telescope Mount
#5337 **$46.34**



Orion® SkyScanner™ 100mm TableTop Reflector
#10012 **$123.59**



FunScope 76mm TableTop Reflector Telescope Moon Kit
#10033 **$66.94**



Orion® StarShoot™ G3 Deep Space Color Imaging Camera
#53082 **$411.99**

Retail prices shown are current as of 03/19/15 from Orion. Prices are subject to change without notice. Please check OrionTelescopes.com for the most current pricing. Dealer pricing and/or promotions may vary.

OrionTelescopes.com

Shop Orion On-the-Go. Easy Access right on your Smartphone.

FROM THE **EDITOR**

BY DAVID J. EICHER



COURTESY JEFF HESTER

Introducing columnist Jeff Hester

This month, we have the first of a long series of delights — the distinguished astronomer Jeff Hester begins a new monthly column, "For Your Consideration" (p. 10).

Hester will keep us apprised of all manner of thoughts and interesting notions from the science of astronomy and cosmology, in a very sharp and witty way. If you don't know him, here's an introduction:

After earning his doctorate in space physics and astronomy from Rice University, Hester moved west to the California Institute of Technology. There he joined the team responsible for the Hubble Space Telescope Wide-Field and Planetary Camera (WFPC). So began a career that placed Hester in a front-row seat for some of the most extraordinary events in the history of science.

Shortly after the launch of Hubble, Hester found himself sitting in front of a computer on live national television when the first image from the telescope was radioed to the ground. It was that image that alerted people to the possibility that something was amiss. He went on to join the science team responsible for WFPC2, the camera that *fixed* Hubble. What was his take on the experience when the first image was radioed back after the servicing mission? "It was a lot more fun the second time around!"

During his scientific career, Hester has worked on a variety of astrophysical questions. He is especially well known for his work on star formation, supernova remnants, pulsar winds, and the early history of the solar system. His Hubble image of the Eagle Nebula (commonly referred to as "The Pillars of Creation") is arguably the most famous astronomical image of all time. It was featured on a U.S. postage stamp, and last year *Time* magazine selected the image as among the 100 most influential photographs in history.

Hester is known for the depth and breadth of his insights as well as his uncommon ability to communicate complex ideas in an accessible and entertaining way. He has appeared in dozens of televised documentaries discussing his work, not to mention a commercial for an Irish hard cider. Broadcaster Hugh Downs referred to Hester as "one of the greatest explainers in our midst today."

Hester recently took early retirement from Arizona State University after spending 20 years on the faculty. He is now working as a speaker and certified professional coach, sharing his experience and insight with individuals and organizations looking for success in changing times. "Everyone looks at the world through their own lens. I help them sharpen their focus," he says. You can find his website at www.jeff-hester.com.

You will enjoy his future thoughts about the cosmos!

Yours truly,



David J. Eicher
Editor

Follow the Dave's Universe blog:
www.Astronomy.com/davesuniverse
Follow Dave Eicher on Twitter: **@deicherstar**

Astronomy

Editor David J. Eicher
Art Director LuAnn Williams Belter

EDITORIAL STAFF
Senior Editors Michael E. Bakich, Richard Talcott
Production Editor Karri Ferron
Associate Editors Eric Betz, Korey Haynes
Editorial Associate Valerie Penton

ART STAFF
Senior Graphic Designer Chuck Braasch
Illustrator Roen Kelly
Production Coordinator Jodi Jeranek

CONTRIBUTING EDITORS
Bob Berman, Adam Block, Glenn F. Chaple, Jr., Martin George, Tony Hallas, Phil Harrington, Liz Kruesi, Ray Jayawardhana, Alister Ling, Steve Nadis, Stephen James O'Meara, Tom Polakis, Martin Ratcliffe, Mike D. Reynolds, Sheldon Reynolds, Erika Rix, John Shibley, Raymond Shubinski

EDITORIAL ADVISORY BOARD
Buzz Aldrin, Marcia Bartusiak, Timothy Ferris, Alex Filippenko, Adam Frank, John S. Gallagher III, Daniel W. E. Green, William K. Hartmann, Paul Hodge, Anne L. Kinney, Edward Kolb, Stephen P. Maran, Brian May, S. Alan Stern, James Trefil

Kalmbach Publishing Co.

President Charles R. Croft
Vice President, Editorial, Publisher Kevin P. Keefe
Senior Vice President, Sales & Marketing Daniel R. Lance
Vice President, Consumer Marketing Nicole McGuire
Corporate Art Director Maureen M. Schimmel
Art and Production Manager Michael Soliday
Corporate Advertising Director Ann E. Smith
Circulation Manager Ken Meisinger
Single Copy Specialist Kim Redmond

ADVERTISING DEPARTMENT
(888) 558-1544
Advertising Sales Manager Jamie Rinehart
Advertising Sales Representative
Dina Johnston, djohnston@kalmbach.com
Ad Services Representative
Christa Burbank, ads@astronomy.com

RETAIL TRADE ORDERS AND INQUIRIES
Selling *Astronomy* magazine or products in your store:
Phone (800) 558-1544, Press 3
Outside U.S. and Canada (262) 796-8776, ext. 818
Fax (262) 798-6592
Email tss@kalmbach.com
Website www.Retailers.Kalmbach.com

CUSTOMER SALES AND SERVICE
Phone (800) 533-6644; **Fax** (262) 796-1615
customerservice@kalmbach.com

SPECIAL EMAIL ADDRESSES
Ad Sales adsales@astronomy.com
Ask Astro askastro@astronomy.com
Books books@astronomy.com
Letters letters@astronomy.com
Products products@astronomy.com
Reader Gallery readergallery@astronomy.com

Editorial phone: (262) 796-8776; advertising: (888) 558-1544; customer service & sales: (800) 533-6644; outside the U.S. and Canada: (262) 796-8776, ext. 421, Monday through Friday, 8:30 A.M. to 4:30 P.M. CT, Fax: (262) 796-1615; Email: customerservice@kalmbach.com. Please include your name, mailing address, and telephone number with any correspondence.

Copyright © 2015 Kalmbach Publishing Co., all rights reserved. This publication may not be reproduced in any form without permission.

Printed in the U.S.A. Allow 6 to 8 weeks for new subscriptions and address changes. Subscription rate: single copy: $5.99; U.S.: 1 year (12 issues) $42.95; 2 years (24 issues) $79.95; 3 years (36 issues) $114.95. Canadian: Add $12.00 postage per year. Canadian price includes GST, payable in U.S. funds. All other international subscriptions: Add $16.00 postage per year, payable in U.S. funds, drawn on a U.S. bank. Expedited delivery service surcharges: Domestic first class $30/yr; Canadian air $30/yr; International air $60/yr. BN 12271 3209 RT. Not responsible for unsolicited materials.

Follow *Astronomy*

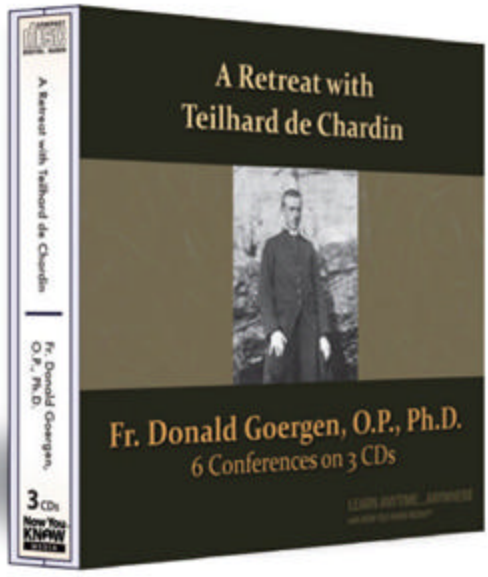
www.twitter.com/AstronomyMag
www.facebook.com/AstronomyMagazine
plus.google.com/+astronomymagazine

Alliance for Audited Media
KALMBACH PUBLISHING CO.
Please Recycle This Magazine

WorldMags.net

Experience the Towering Scientific and Mystical Thought of Pierre Teilhard de Chardin

LIMITED TIME OFFER
70% off
ORDER IN NEXT 30 DAYS



Now You KNOW MEDIA

Presented by gifted professor, author, and retreat leader Rev. Donald Goergen, this 6-conference series will capture your scientific and spiritual imagination. These powerful conferences are life-changing.

Trained as a paleontologist and ordained as a Jesuit priest, Teilhard was one of the most influential writers of the twentieth century. His cosmic and evolutionary thought continues to enthrall men and women around the world. Seamlessly weaving together science with theology, he unveiled a powerful vision of the universe. By listening to Rev. Goergen's conferences on Teilhard, you will explore how we are all called to grow spiritually. Whatever your own calling in life is, Teilhard's profound wisdom will speak to you.

Teilhard's mystical vision of the world was both universal and deeply personal. Rev. Goergen's moving retreat will lead you to discover how this vision can guide your personal growth today. Let Teilhard accompany you and offer wise guidance in your journey.

This program was originally part of Rev. Goergen's *A Retreat with Four Spiritual Masters*.

Must order within 30 days of issue date

1-800-955-3904

https://www.NowYouKnowMedia.com/Pierre

Now You Know Media, Inc. • 12115 Parklawn Dr., Suite B • Rockville, MD 20852

A Retreat with Teilhard de Chardin

Presented by
Rev. Donald Goergen, O.P., Ph.D.

Conference Titles

1. Creation and Evolution
2. A World-Affirming Spirituality
3. The Cosmic Christ
4. The Eucharist
5. Personalization
6. Christ and the Universe

A Retreat with Teilhard de Chardin
6 Conferences (25 minutes/conference)
+ electronic retreat guide

SAVE $46

3 CD Set ~~$65.95~~ **SALE $19.95**

Coupon Code: A1858

+ $3.95 Shipping & Handling
100% Satisfaction Guarantee

Now You Know Media's mission is to bring you the world's premier religion professors and retreat leaders. Unparalleled for their scholarship and insight, these presenters will touch your heart and captivate your intellect. Visit our website, www.NowYouKnowMedia.com, to browse our growing catalog of over 250 courses and retreats available in CD, DVD, and MP3 formats.

WorldMags.net

COMPELLING SCIENCE for curious minds.

10 issues JUST $19.95

Newton's apple. Edison's lightbulb. Hawking's astrophysics. Look where curiosity can lead you.

Every issue of *Discover* expands your mind with:

- The latest news, theories, and developments in science and space.
- Compelling stories and breakthroughs in health, medicine, and the mind.
- Environmental issues and their relevance to daily life.
- Thought-provoking contributions by award-winning editors, opinion makers, Nobel laureates, and renegade scientists.
- Amazing photography and stunning graphics that capture the awe and wonder of science.



Subscribe to *Discover* magazine and see where your curiosity takes you.

Go to DiscoverMagazine.com

or call 800-829-9132

Available in print or digital format.

P25325

WorldMagazines

QG QUANTUM GRAVITY

EVERYTHING YOU NEED TO KNOW ABOUT THE UNIVERSE THIS MONTH . . .

HOT BYTES >>

TRENDING TO THE TOP



COMET WATCH
Rosetta passed within 4 miles (6 kilometers) of Comet 67P/Churyumov-Gerasimenko, giving scientists their best view yet.



#YEAROFPLUTO
NASA released New Horizon's latest long-distance look at Pluto to celebrate the birthday of the world's finder, Clyde Tombaugh.



THE PERFECT RING
Hubble shots of Beta Pictoris, the only stellar debris disk with an imaged giant planet, saw little change in 15 years, implying near uniformity.

SNAPSHOT

How large is the universe?

We really don't know the answer, but we know that it's at least as large as the Big Bang and cosmic expansion tell us.

The concept of the size of the universe has taken huge strides forward in just the last few years. There was a time not long ago when astrophysicists didn't know how big the cosmos is. The Big Bang theory reminds us that once the universe was small. We know the fastest any radiation can travel is the speed of light. We also know the universe is 13.8 billion years old.

At first blush, you might expect radiation across the universe to expand by something like 30 billion light-years after that time. But that's too simplistic. The Big Bang wasn't like a bomb going off; space itself expands over time so that 1 centimeter in the early cosmos becomes 2 centimeters and so on. Because of space-time's expansion, we know the universe is at least 93 billion light-years across.

But there's a major proviso to that number, which refers to the visible universe. Our visible universe may not be the entire universe, and on top of that, some cosmologists even believe the cosmos could be infinite.

So at best, we can say the universe is at least 93 billion light-years across, which is a pretty good hike.

— David J. Eicher



TONY HALLAS (NGC 6946); ESA/ROSETTA/NAVCAM – CC BY-SA IGO 3.0 (COMET WATCH); NASA/APL/SwRI (#YEAROFPLUTO); NASA/ESA/D. APAI AND G. SCHNEIDER (UNIV. OF ARIZONA) (THE PERFECT RING)

The universe holds at least 125 billion galaxies, and may contain far more than that, a number that seems staggering compared with a single galaxy like NGC 6946.

WorldMags.net



FOR**YOUR**CONSIDERATION

BY JEFF HESTER

Our roots in the cosmos

There's nothing mythical about this creation story.



This still from the Illustris Simulation shows a universe like ours re-created on a hard drive. Blue and purple dark matter provides the framework on which rest all of the galaxy clusters of the universe, shown here in brilliant orange and red. ILLUSTRIS COLLABORATION

Editor's note: With this issue we welcome Jeff Hester, who is well known for his work with the Hubble Space Telescope. His credits include Hubble's most famous image, "The Pillars of Creation." He now works as a certified professional coach, keynote speaker, and thinking partner, helping people find success in changing times. In this new monthly column, he will share his thoughts on just what makes it so remarkable to be human.

Count yourself lucky! Not everyone can say they were present at the moment humankind's conception of itself changed. But you can.

Since the dawn of history, humans have built whole civilizations around myths and fables linking our existence to a mystical celestial realm. And yet in the end it took less than a lifetime to overturn that whole framework and replace it with something radically different: real answers.

The last few decades have seen sweeping changes not only in astronomy, but in every scientific field from biology and geology to particle physics and information theory. Drawing on insights from all of those fields and more, we have traced our own cosmic journey back to the beginning of time. That story doesn't hinge on appeal to authority or interpretation of revealed truth. There are things left to learn, but there are no glaring failures that have to be swept under the rug. Each chapter is grounded firmly in hard-won knowledge, wrested from the universe through the potent combination of human creativity and the unforgiving standards of scientific knowledge.

At this point, a historian might raise an eyebrow. "Sure, if you want to know about ancient Greece, you can visit ruins; you can study artifacts; you can read Homer. But history is always open to interpretation. It's not like you can sit down with an engineer and go over a video of them building the Parthenon!"

Historians might have to put up with such annoying limitations, but astronomers and cosmologists do not. When you look at the center of the Milky Way, you see it as it was 27,000 years ago, during a time when our ancestors were Cro-Magnons living in caves in Europe. Turn a backyard telescope on the Virgo Galaxy Cluster, and you are looking back almost 66 million years to the time when an asteroid impact ended the 160-million-year reign of the dinosaurs.

So it goes, all the way back to the birth of the universe itself. When we look at the sky's dim microwave glow, we see the universe as it was 13.8 billion years ago. There is no trick here, no twisted meanings. An image of the microwave sky is *literally* a baby picture of the cosmos.

Last year saw one of the most extraordinary results in the history of science. That result came not from a powerful new telescope or high-energy particle accelerator. Instead, it emerged from 19 million CPU hours of supercomputer time spent doing physics calculations.

The Illustris Simulation is no less than an effort to *calculate* the evolution of the universe. The calculations started with the conditions in the early universe (remember that baby picture?), along with well-understood rules like general relativity and the physics of star formation and evolution. Then computers turned the crank in cold, methodical fashion, following what happened over the next 14 billion years. When it was done, the computer showed large-scale structure much like what we see in today's universe and galaxies so realistic that even experts have trouble telling them apart from images of the real thing.

Here is what we know. Start a universe like ours was in the beginning. Hydrogen and helium *will* form in an early hot bath of matter and energy. As things cool down in that expanding universe, clumps of matter *will* form and ultimately collapse under the force of gravity to form galaxies and large-scale structure. Clouds of gas *will* collapse to form stars, and within those stars nuclear forces *will* build new chemical elements. Stellar winds and explosions *will* blow that chemically enriched material back into interstellar space. As stars continue to form, flat rotating disks *will* form around those stars and give birth to planets laden with new elements. And on at least one such planet (and probably many, many more), chemistry and the inexorable algorithm of evolution *will* lead to the rise of the remarkable phenomenon we call life.

Why will all of this happen? All of this will happen because physics works!

Indeed, we live in an extraordinary moment in the history of our species. But it truly is a moment, a historical blink of the eye. Cultures change more slowly, and this is a *big* change! Once we thought ourselves the products of special creation sitting at the center of the universe. Where does science get off trying to demote us to insignificant specks adrift in a vastness beyond comprehension? I can understand how some might recoil from that thought.

I can understand that reaction, but I do not share it. You see, when I look at the individual human mind, I'm blown away. In the midst of all we have seen, a spark of consciousness arose, capable of pondering its own existence. Remarkable!

The heavens might be a place of grandeur, but they are not the home of meaning or purpose. That honor resides right here, in the thoughts and experiences and aspirations of each of us.

I'll settle for that any day.

Jeff Hester is a keynote speaker, coach, and astrophysicist. Follow his thoughts at **jeff-hester.com.**

BROWSE THE "FOR YOUR CONSIDERATION" ARCHIVE AT **www.Astronomy.com/Hester.**

WorldMags.net



Laser crime and punishment

Safety is paramount with these astronomical tools.

Green lasers may have replaced telescopes as the most common item in the astro toolkit. Their narrow beams are perfect for pointing out stars.

But there's a dark side.

Three years ago, a Northern Californian named Sergio Rodriguez kept aiming a high-powered laser at a police helicopter. Result: He was recently sentenced to 14 years in prison.

Of the 17,725 reported U.S. laser strike incidents from 2005 through 2013, just 134 arrests have been made, resulting in 80 convictions. But enforcement is increasing.

Let's rewind to the beginning.

In 1957, Columbia University doctoral student Gordon Gould figured out a way to make light waves march in unison, a possibility predicted a half-century earlier by Albert Einstein. Two years later, he coined that catchy word in his paper: "The LASER, Light Amplification by Stimulated Emission of Radiation." Bell Labs also was furiously trying to make photons pulse in lockstep and, after building the first usable laser in 1960, began a patent fight that wasn't fully resolved for 28 years. Historians still debate who was the laser's inventor.

Nobody foresaw how quickly this invention would find its way into daily life or how inexpensive it would soon become. It took a mere 14 years for the Universal Product Code — with its black, variable-thickness bars — to be created and agreed upon. In a little-noticed moment the same summer Nixon resigned, the National Cash Register Company's test system started at a Marsh Supermarket in Troy, Ohio. On June 26, 1974, at 8:01 A.M., cashier Sharon Buchanan scanned Clyde Dawson's 10-pack of Wrigley's gum, and thus began the bar code. The gum (presumably unchewed) and the receipt are on display in Washington, D.C.'s Smithsonian Institution National Museum of American History.

Supermarket lasers, like those in CD players, use about 5 milliwatts, which is also the legal power limit for hand-held devices like lecture pointers. Those in DVD players use up to 10 mW, while DVD burners require 100 mW. Lasers in surgery employ 30,000 to 100,000 mW, meaning 30 to 100 watts, to effortlessly cut through flesh.

Everyday 5 mW red lasers remain the favorite for pointers and cat toys, and are the least expensive at a few dollars apiece. But they don't create a visible beam in the night sky. That's because their linearly polarized emissions can't efficiently illuminate airborne dust or tiny water drops. For a visible ray, you need a green laser or one of the newer blue ones, which are all circularly polarized. Because green is perceived far more readily than any other color, it's the only one that can create a visible beam using the lawful 5 mW. In bright moonlight or in light-polluted cities, a boosted-up 30 mW green laser is desirable for a sharp beam, though it cannot legally be marketed as a pointer.

These require prudence. While no confirmed retinal damage from a 5 mW red laser exists, the higher-power green models carry a definite risk to vision. But dangerous or not, lasers are important astronomy tools.

DANGEROUS OR NOT, LASERS ARE IMPORTANT ASTRONOMY TOOLS.

The Apollo 11, 14, and 15 crews each left corner cubes on the Moon that bounce light back toward its source like reflective highway signs. The Apollo 15 array is particularly huge and effective. Several observatories, like New Mexico's APOLLO, routinely send laser pulses moonward to precisely measure the 2½-second round-trip travel time. It's tricky because even a laser beam spreads out. A laser spot on the Moon is just over a mile wide. In this 1.8-kilometer circle, only one laser photon in 30 million manages to hit a cube. Then only one in 30 million of the returning photons reaches the detecting telescope. You'd think the modest 2.3W laser couldn't possibly be successful. But it is. Results provide confirmation of gravity's stability. They also reveal that the Moon spirals away from us at the rate of 1.5 inches (3.8 centimeters) per year.

The past decade has seen a huge increase in the sale of ever more powerful models with teen-friendly names like Spyder and Krypton. Recently, I tried out my friend Matt's new green and violet lasers. One was a 1,000 mW model — a full watt. It instantly popped dark-colored balloons. Fun! But imagine what it would do to your retina. The mere reflection is hazardous, especially after hitting chrome or glass.

Without much thought to the consequences, some point lasers at aircraft. I myself have been struck while piloting my plane at night. No one has yet been permanently blinded, but commercial pilots have been incapacitated for hours.

Bottom line: Please be careful. We don't want the government banning green lasers. Keep beams far from planes. You wouldn't enjoy living in a prison, given its light-polluted rec yard.

Contact me about my strange universe by visiting **http://skymanbob.com.**

FROM OUR INBOX

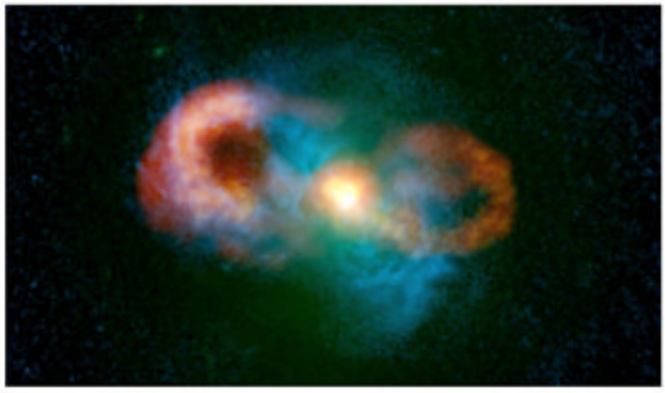
What's your sign?

I enjoyed reading Stephen James O'Meara's column in the March issue (p. 16). I am one of the Sagittarians born under Ophiuchus (December 16). I had been unaware of the distinction and had always considered myself the former. Although I never placed any credence in the pseudo-science of astrology, there were often believers I'd meet through the years who would ask, "What's your sign?" As a mailman for 33 years, I would playfully answer, "My sign is 'Beware of Dog.'" More recently, I like to tease astrologers by answering "Ophiuchus." Usually they've never heard of it, and I get to explain what that means. Thanks to you, I can show them a copy of your column, too! **— Gary Cronin,** West Babylon, New York

We welcome your comments at Astronomy *Letters, P. O. Box 1612, Waukesha, WI 53187; or email to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

WorldMags.net

LHC REBOOT. The Large Hadron Collider (LHC) had a minor short circuit that delayed its restart in March. Several years of upgrades will soon let the accelerator hit energies never before seen, refining the Higgs boson and probing dark matter.



STAR STOPPAGE. In this composite image of the Teacup Galaxy, red and yellow radio data reveal jets launched by the central supermassive black hole that are destroying the star-forming gas nearby, shown in blue. C. HARRISON/A. THOMPSON/B. SAXTON/NRAO/AUI/NSF/NASA

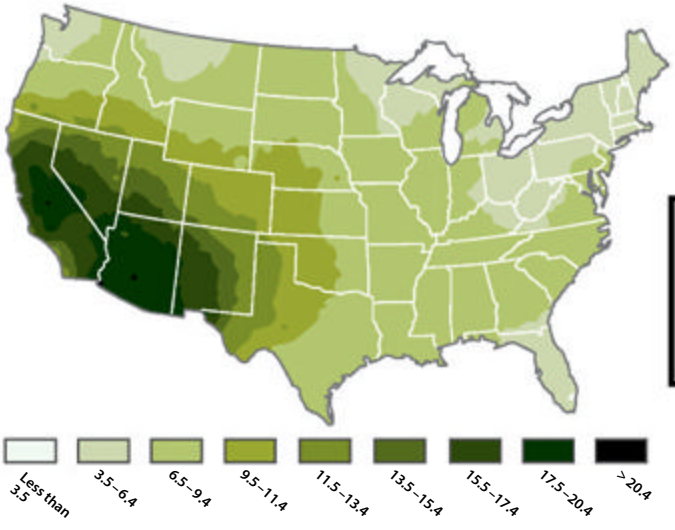
RADIO-FAINT GALAXY SURPRISES BY STOPPING STAR FORMATION

Scientists using the Very Large Array (VLA) in New Mexico are discovering that a process that can terminate star-formation activity in rare radio-bright galaxies also occurs in their less extreme brethren. For years, radio astronomers had observed powerful jets of material from supermassive black holes at the center of radio-bright galaxies plowing through the surrounding gas and squelching star formation. But no one knew if the same situation was occurring in more common galaxies as they stopped actively producing stars.

To find out, a team of astronomers led by Chris Harrison of Durham University in the United Kingdom began studying radio-quiet galaxies that appeared to have active supermassive black holes at their centers. J1430+1339, also known as the Teacup Galaxy, provided some insight. The VLA revealed "bubbles" extending 30,000 to 40,000 light-years from the galaxy and jet-like structures closer in, telling astronomers that the Teacup's central supermassive black hole is stopping star formation in a fashion similar to that found in a radio-bright galaxy.

"This 'storm' in the Teacup means that the jet-driven process in which a black hole is removing or destroying star-formation material may be much more typical than we knew before and could be a crucial piece in the puzzle of understanding how the galaxies we see around us were formed," Harrison says. His team's study appeared in the February 10 issue of *The Astrophysical Journal*. **— Karri Ferron**

AVERAGE NUMBER OF CLEAR DAYS IN JUNE



ASTRONOMY: MICHAEL E. BAKICH AND ROEN KELLY, AFTER NOAA

FAST FACT

Most observers use the clear nights in June to observe star clusters and nebulae along the Milky Way.

BRIEFCASE

SUPERNOVA IN THE MAKING

Astronomers using the European Southern Observatory's Very Large Telescope discovered a white dwarf pair hidden inside planetary nebula Henize 2-428. The couple orbit each other so closely that within 700 million years they will spiral into one massive star, triggering a supernova explosion. Merging white dwarfs have long been a theoretical cause of type Ia supernovae, but this is the first time astronomers have seen such a pair on the road to their destruction. Their study appeared in *Nature* March 5.

BATTERED MARS METEORITE

A martian meteorite nicknamed "Black Beauty" gives scientists a chance to study a piece of Mars' surface up close. Most such space rocks are hardened volcanic material, but this one appears to be uniquely representative of Mars' crust. It contains multiple rock types mashed together by the strain of the many impacts that scar Mars' face, and the rock's spectra, according to research published May 15 in the journal *Icarus*, matches that taken by Mars orbiters of the planet's surface.

SAFETY ZONE

In papers from the August 2014 and February 2015 issues of the *Publications of the Astronomical Society of Japan*, astronomers using the Atacama Large Millimeter/submillimeter Array announced seeing organic molecules safely residing around the supermassive black hole at the center of spiral galaxy M77. Previously, scientists thought the violent radiation environment around black holes would destroy complex molecules, but they instead appear to be shielded by dense regions of dust and gas. **— Korey Haynes**



SHUTDOWN. New data from two X-ray observatories prove that black hole winds are nearly spherical and strong enough to blow gas, the fuel of star formation, completely out of their host galaxy. NASA/JPL-CALTECH

A mighty black hole wind

It's commonly accepted that supermassive black holes emit winds powerful enough to blow away their host galaxy's supply of gas, shutting down star formation and strongly affecting galactic evolution. But observing these winds directly is tricky. Researchers announced February 19 that they had successfully used NASA's Nuclear Spectroscopy Telescope Array (NuSTAR) and ESA's XMM-Newton telescope to observe high- and low-energy X-rays, respectively, blasting material out of black hole PDS 456. Together, the two telescopes delivered observational proof that powerful winds blow in all directions from black holes, with enough force to blow out gas and quench star formation. **— K. H.**

WorldMags.net

TWINKLE, TWINKLE. British scientists announced plans for a small satellite named "Twinkle," which will analyze the atmospheres of thousands of known exoplanets, searching for spectral fingerprints of gases like water and methane.

NASA visits the solar system's largest asteroid

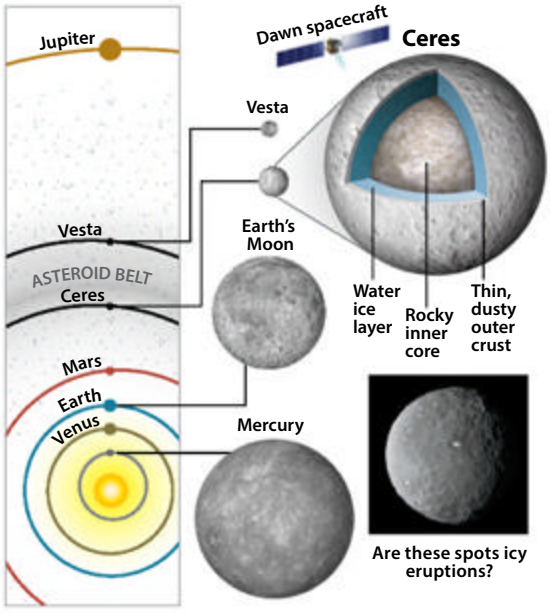
There was no dramatic entry. No high-risk maneuvers or nail-biting rocket firing. If NASA's Dawn spacecraft missed on its slow crawl into orbit around the dwarf planet Ceres early on March 6, engineers would have just tweaked the weak thrust of the ion engines and tried again. Instead, mission managers say the real drama will be the science unveiled as NASA chronicles the history of the largest unexplored body in the inner solar system.

"Since its discovery in 1801, Ceres was known as a planet, then an asteroid, and later a dwarf planet," said Dawn Chief Engineer Marc Rayman on the 6th. "Now, after a journey of 3.1 billion miles (4.9 billion kilometers) and 7.5 years, Dawn calls Ceres home."

Ceres — the largest member of the main asteroid belt — is Dawn's second target. The spacecraft spent 14 months exploring Vesta, the second-largest asteroid. Together, the pair make up 40 percent of the belt's mass.

The rest of the belt represents a multi-billion-year record of collisions; however, astronomers believe these two icy bodies are protoplanets — the fossilized seeds of planets that might have been. Dawn's images of Ceres already imply material moved from the interior onto the surface relatively recently. Vesta is covered in craters, but Ceres has large regions where the surface is smooth.

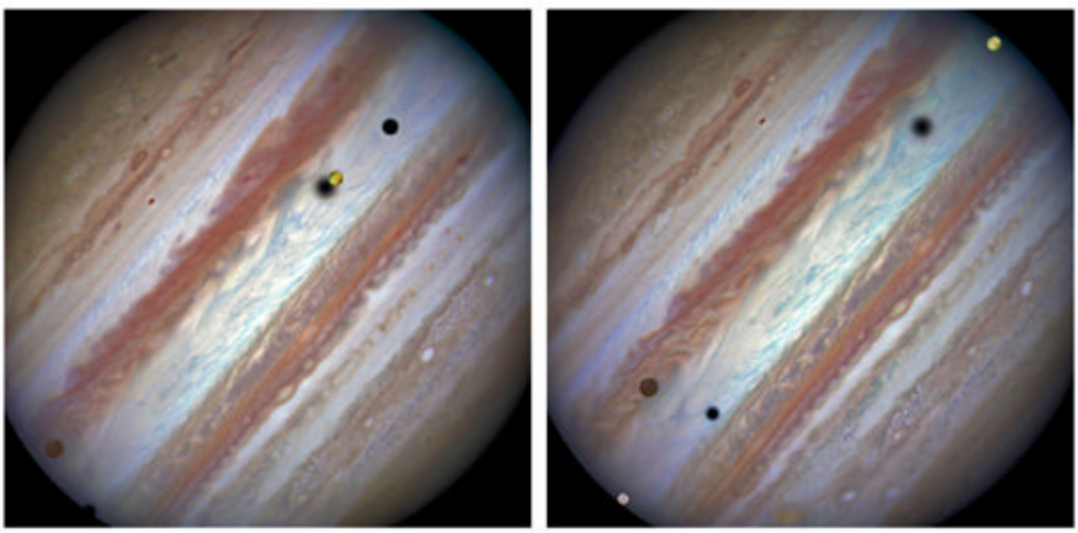
Its density implies a mix of rock and ice, but the world's exact makeup is a mystery Dawn hopes to explain. The European Space Agency's Herschel spacecraft found evidence of water near the dwarf planet last year, so NASA is eagerly seeking plumes streaming off the surface. And strange bright spots, seen only on Ceres, might have already delivered. In talks given at March's Lunar and Planetary Science Conference in Houston, Dawn scientists said the spots might be the very ice volcanoes they'd hoped to find, giving Dawn success upon arrival. **— Eric Betz**



CERES SUCCESS. NASA's Dawn spacecraft reached Ceres in March, but it approached from the far side, leaving scientists in the dark until mid-April. NASA/JPL-CALTECH/UCLA/MPS/DLR/IDA; *ASTRONOMY*: ROEN KELLY

2.7 million mph (1,200 km/s) The breakneck speed of star US 708, fast enough to launch it out of the Milky Way.

Jupiter moons captured in rare triple transit



NASA/ESA/THE HUBBLE HERITAGE TEAM (STScI/AURA)

SHADOW PLAY. On January 24, the Hubble Space Telescope captured an event only seen once or twice a decade: three of Jupiter's moons crossing the giant planet's face and casting their shadows on its banded surface. In the image at left, showing the beginning of the triple-moon transit, brownish Callisto and orange-yellow Io are visible, along with their shadows and that of Europa. Some 42 minutes later (right image), yellow-white Europa has entered the scene at lower left, while Io no longer casts its shadow on Jupiter. **— K. F.**

QUICK TAKES

MOON SUPPLIES
Lunar hydrogen deposits — possibly a sign of water — are more abundant on south polar-facing crater slopes, NASA's Lunar Reconnaissance Orbiter found. The deposits might one day supply water, fuel, and air.

MAGNETIC STORMS
NASA launched its four Magnetospheric Multiscale spacecraft in March to study magnetic fields connecting and disconnecting around Earth. Such explosive energy releases are involved in technology-disrupting space weather.

EXPLODING SUNS
A study of planetary nebulae — a Sun-like star's final stage — found "water fountains," explosions that occur as red giants use up their nuclear fuel. It shows some suns have surprising last gasp eruptions.

DEEP-FRIED ICE CREAM
Lab tests on ice and organics show comet surfaces get hard and crystalize on approach to the Sun as carbon-containing molecules are ejected — sort of like deep-fried ice cream.

NEW SPACELINER
The European Space Agency launched a new spaceplane to advance reusable transport capabilities. The craft climbed to 75 miles (120km) and reentered the atmosphere, splashing down in the Pacific Ocean.

BLOCKBUSTER FIND
Visual effects from the movie *Interstellar* led to a February paper in *Classical and Quantum Gravity*. The code mapped light beams moving through a black hole's space-time, showing how they would be bent in front of a filmmaker's camera.

DISAPPEARING DWARF
The Very Large Telescope's new instrument, SPHERE, failed to find a suspected brown dwarf around V471 Tauri, a strange binary. SPHERE's first science has astronomers after a new theory of the odd behavior.

FRONTIER STARS
Brazilian astronomers found new star clusters at our galaxy's edge — far from the inner disk where most form. The group suspects a supernova booted the star-forming dust and gas, or it was stripped as our galaxy skimmed a neighbor. **— E. B.**

WorldMags.net



BY GLENN CHAPLE

Asteroid awareness

Honor the inaugural Asteroid Day by learning the facts about a potential impact.

It's out there — an asteroid as big as a battleship whose orbit brings it dangerously close to Earth. At some time in the future — a few thousand years from now or perhaps within your lifetime — it's destined to collide with our planet. If it strikes land near a large city, millions will perish. A touchdown at sea will produce tsunamis that would devastate coastal cities and communities. What I describe isn't the fanciful scenario of some sci-fi disaster movie. It's a fact-based astronomical prediction.

The solar system is littered with rocky debris, most of which is pea-sized or smaller. When one of these cosmic bullets encounters our atmosphere, it disintegrates harmlessly as a meteor. Much more rare are fist- to boulder-sized rocks that produce spectacular, exceptionally bright meteors called fireballs. Really large space rocks create bolides, which are fireballs that explode in the upper atmosphere (an airburst), or super-bolides that reach the ground as meteorites — in either case causing serious damage. According to NASA, one or two of these car-sized bodies hits Earth's atmosphere each year. Astronomers estimate those that cross our orbit number in the millions.

While a strike by a 6-mile-wide (10 kilometers) asteroid can cause global extinction (just ask any dinosaur who was around 66 million years ago), a hit by even a small asteroid can wreak havoc. On June 30, 1908, an asteroid or small comet about 130 feet (40 meters) across and traveling at a speed of 33,500 mph (54,000 km/h) streaked into the atmosphere, exploding some 5 miles (8km) over Tunguska in the Russian tundra. An energy release equivalent to as much as a thousand times that generated by the atomic bomb that destroyed Hiroshima leveled 800 square miles (2,000 square km) of forestland. Fortunately, the impact site was largely unpopulated.

More recently, though, Russia was the unlucky recipient of yet another space rock, this time over an inhabited area. At 9:20 A.M. local time February 15, 2013, an asteroid 65 feet (20m) in diameter generated a brilliant fireball that lit up the sky before exploding 18.4 miles (29.7km) above the city of Chelyabinsk. The shock wave shattered windows for miles in all directions and injured nearly 1,500 people. The energy from the blast equaled 20 to 30 Hiroshima bombs. Coincidentally, on the same day as the Chelyabinsk incident, the slightly larger near-Earth asteroid 2012 DA_{14} sped past our planet at a distance of just 17,200 miles (27,700km). Perhaps I should correct my opening sentence. *It* isn't out there. *They're* out there!



Scientists know the asteroid threat is real. Even a 165-foot (50 meters) space rock could cause regional devastation.
JAMES THEW/ISTOCK/THINKSTOCK

Understanding the need to discover and monitor asteroids that threaten Earth, a group of scientists including the UK Astronomer Royal Lord Martin Rees, astrophysicist/Queen guitarist Brian May, CEO of The Planetary Society and "Science Guy" Bill Nye, and Apollo 9 astronaut Rusty Schweickart has promoted the adoption of Asteroid Day. Its date, June 30, 2015, coincides with the anniversary of the Tunguska event. The goal of Asteroid Day is to educate the world about what asteroids are, how frequently they impact Earth, and how we can protect ourselves from potential disasters. *Astronomy* is proud to be among the partners of Asteroid Day.

Asteroid Day advocates aren't being alarmist; they're being realistic. As May notes, "We are currently aware of less than 1 percent of objects comparable to the one that impacted at Tunguska, and nobody knows when the next big one will hit." Nye adds, "Someday humankind will have to prevent an asteroid impact. The first step toward protecting our planet is to find and track the swarm of space rocks that cross orbits with Earth." For more information on Asteroid Day 2015, log on to www.asteroidday.org. Also, be sure to check out *Astronomy* Editor David J. Eicher's *Real Reality Show* video "Why Asteroids Should Be Taken Seriously" at www.Astronomy.com/realreality.

Much of the work of locating and tracking near-Earth objects (NEOs) will be done by professional astronomers and amateurs with sophisticated equipment. The rest of us can pay homage to Asteroid Day by turning our telescopes toward Ceres, the asteroid (more properly, "dwarf planet") currently being visited by the Dawn spacecraft.

This month, Ceres flirts with the 4th-magnitude star Omega (ω) Capricorni. At 8th magnitude, the asteroid is bright enough to be visible through the smallest of telescopes. To find Ceres, use a low-power eyepiece and star-hop from Omega to the predicted location of Ceres. Granted, the minute stellar speck you encounter may not be as visually inspiring as the images currently being sent by Dawn, but you might get a feeling of awe and wonder knowing that a craft from Earth is circling it. Whether you actively engage in an NEO search or simply gaze at Ceres from your backyard, have a great Asteroid Day!

Questions, comments, or suggestions? Email me at gchaple@hotmail.com. Next month: A look back in time at the summer's brightest stars. Clear skies!

FROM OUR INBOX

Amazing issue

I've been subscribing to *Astronomy* magazine for many years and have always considered it the best magazine ever published because it has such useful and interesting articles and information. But your March issue with the "500 Coolest Things about Space" is the best ever! Thanks to your staff for putting it together. It's an amazing presentation of all the wonders of the universe. **— Keith Gunnar,** Langley, Washington

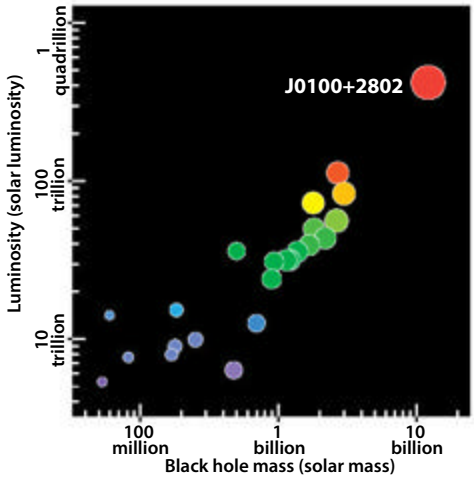
BROWSE THE "OBSERVING BASICS" ARCHIVE AT **www.Astronomy.com/Chaple.**

WorldMags.net

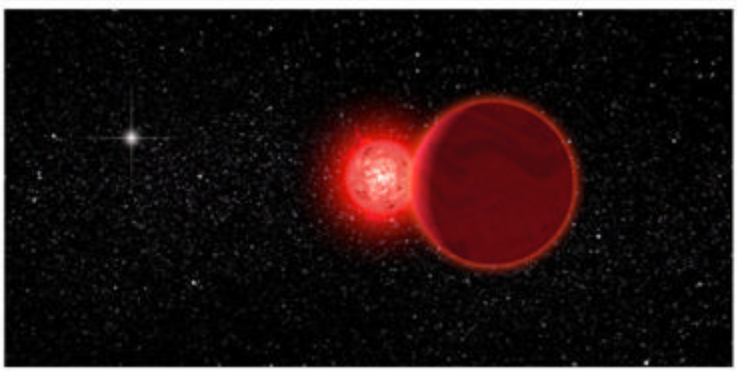
Monster black hole found at cosmic dawn

Quasars are the brilliantly luminous objects we see when intensely heated material spirals in toward a supermassive black hole, giving off enormous amounts of energy. Their brightness means they are the most distant, and hence oldest, objects we are able to see in the universe. One newly discovered quasar — with the catchy name SDSS J0100+2802 — shines its light from only 900 million years after the Big Bang, with the luminosity of 420 trillion Suns. At over 12 billion solar masses, it dwarfs the supermassive black hole at the center of the Milky Way by over 3,000 times. Scientists from Peking University announced their discovery in the journal *Nature* on February 26.

Astronomers know from black hole observations both near and far that a galaxy's growth is intricately connected to the growth of its central black hole. But it is unknown how this relationship might have changed over the past 13 billion years. The newly discovered black hole managed to grow to an astonishing size at a time when the first stars had only recently emerged, so scientists hope this distant quasar can teach them how galaxies formed and evolved in the infant universe. **— K. H.**



CRUSHING THE COMPETITION. The most distant known quasars are shown here, plotted by their mass and brightness. The latest discovery easily outclasses all of its fellows in both categories. *ASTRONOMY*: ROEN KELLY, AFTER ESO/M. KORNMESSER



CLOSE CALL. Scholz's Star and its companion brown dwarf graze our solar system in this artist's impression of the scene 70,000 years ago. Our Sun shines in the background. MICHAEL OSADCIW/ UNIVERSITY OF ROCHESTER

Small star brushed Oort Cloud

Around 70,000 years ago, a small star squeaked into our solar system on a rapid flyby that lasted for thousands of years. Astronomers say the tiny sun likely had minimal impact on the Oort Cloud, a shell of comets surrounding our local neighborhood, but the encounter serves as a reminder that other perturbers might lurk among nearby stars.

The dim object, informally known as Scholz's Star, was noted in catalogs prior to the discovery, but its location in a crowded region of sky near the galactic plane filled with other small red stars made it anonymous. This one only eventually stood out because it was so close to Earth.

Simulations show the star passed within about 0.8 light-year of the Sun and is now about 20 light-years away. Scholz's Star would have traveled across our sky at a stunning 70 arcseconds per year — seven times faster than the current champion, Barnard's Star. Despite that close pass, the star would have been invisible to the naked eye except possibly during occasional flare-ups.

Comets are blamed for some 30 percent of Earth's craters bigger than 6 miles (10 kilometers) across. And in the past, scientists proposed that a close brush with another star could hurl those ice balls our way. But there's scant evidence for impacts hitting our planet in waves. And searches so far have found few stars that might have passed inside the Oort Cloud, even though scientists predict these encounters could happen 12 times every million years.

And while Scholz's Star is interesting for passing closest, experts say it's extremely unlikely that the flyby would have more than a minimal impact on the Oort Cloud, meaning it would be unlikely to have hurled comets at Earth.

Scientists suspect the European Space Agency's new Gaia mission — built to survey a billion stars and map the galaxy — will find stars that passed even closer or will in the future. **— E. B.**

Telescopes.net
Lunt Engineering 100mm Binoculars

Hands down one of the best Giant binoculars in the world
ED80mm by Explore Scientific


Now with a Fan.

Astro-Optic

The best Finder/220mm Guider you can buy for $89.00
CELESTRON

CGE Pro 1400 HD
Woodland Hills Telescopes
5348 Topanga Canyon Blvd.
Woodland Hills, CA 91364
Mon-Sat: 9am-6pm (PST)
Toll Free: (888) 427-8766
Local: (818) 347-2270
Fax: (818) 992-4486
APOGEE IMAGING • ASA • ATIK • CANON • CELESTRON • CORONADO • EXPLORE SCIENTIFIC • FARPOINT • FLI • JMI • KENDRICK • LUMENERA • LUMICON • MEADE • MOONLITE
OFFICINA STELLARE ORION • QSI • SBIG • SKY-WATCHER USA • SOFTWARE BISQUE • STARLIGHT EXPRESS • TAKAHASHI • TELE VUE • THE IMAGING SOURCE • VIXEN PLANEWAVE

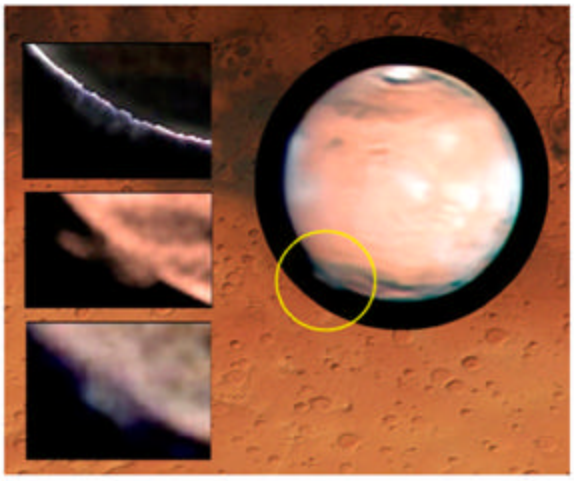
WorldMags.net

DARK MATTER EXTINCTIONS? A biologist tracked the solar system's past movements through the galactic disk, where it might meet increased amounts of dark matter, and thinks he's found a link to comet impacts and geologic activity.

Mysterious Mars clouds stump scientists

A suite of spacecraft currently circle and crawl across the Red Planet, monitoring everything from its ancient past to current weather cycles. So it came as a shock in 2012 when amateur astronomers using relatively small earthbound telescopes started reporting strange clouds high above the martian surface.

At least 18 amateur astronomers captured the clouds over the course of 11 Earth days before they vanished. A second cycle hit soon after. Not one of the armada of martian spacecraft saw the clouds, but a survey of archival Hubble Space Telescope images showed similar features have been recorded in the past.



MARTIAN METEOROLOGY. NASA's bevy of instruments missed these clouds, but watchful amateur astronomers helped researchers calculate the phenomenon's inexplicable heights. GRUPO CIENCIAS PLANETARIAS (GCP) – UPV/EHU

A group of astronomers used the recent amateur observations to measure the clouds' height and came up with some baffling results. If the scientists' measurements are correct, the clouds climb more than 125 miles (200 kilometers), putting them firmly into the ionosphere and exosphere. That's higher than any feature ever seen on Mars. Stranger still, the clouds morphed over the course of observing sessions.

The scientists wrote about their find in the February 26 *Nature* and said that ice particles — possibly carbon dioxide or water — and aurorae might explain the phenomena, but both of those possibilities would defy the current understanding of Mars' atmosphere. The plumes rise to twice the height of typical ice clouds, three times higher than dust storms, and climb even higher than aurorae. Nothing has ever been observed on Mars at this altitude before.

Another ill-fitting alternative would be dust, which would have a tough time circulating so high and be more likely to do so during the day rather than at night — the only time these plumes were seen.

The astronomers noted that strong magnetic activity has been seen in the same region before but added that if these plumes are tied to aurorae, their brightness would be some 1,000 times greater than the earthly version. And solar activity wasn't high at the time. **— E. B.**



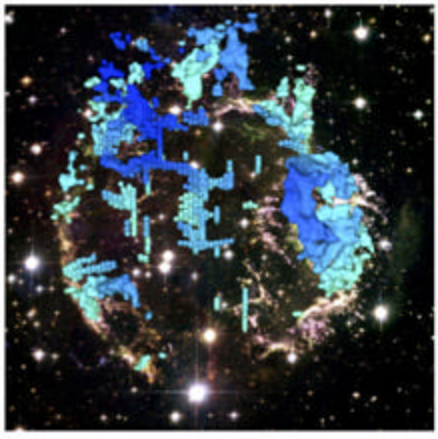


25 years ago in *Astronomy*

In June 1990, Jeff Kanipe shared new results from the Cosmic Background Explorer (COBE), which had just discovered the remarkably uniform temperature of the microwave background. COBE's results were a Nobel Prize-winning accomplishment.

10 years ago in *Astronomy*

In the June 2005 issue of *Astronomy*, Gerry Bryne delved deep into the Sun's frustratingly unpredictable activity cycle, highlighting new research that scientists hoped would allow more accurate future predictions. **— K. H.**



RECONSTRUCTING AN EXPLOSION. Astronomers used infrared observations to determine the velocity of gas (speed toward the observer is indicated in darker blue) throughout Cassiopeia A, revealing the details of a supernova explosion 340 years past. D. MILISAVLJEVIC (CFA)/R. FESEN (DARTMOUTH); BACKGROUND IMAGE: NASA/ESA/HUBBLE HERITAGE TEAM

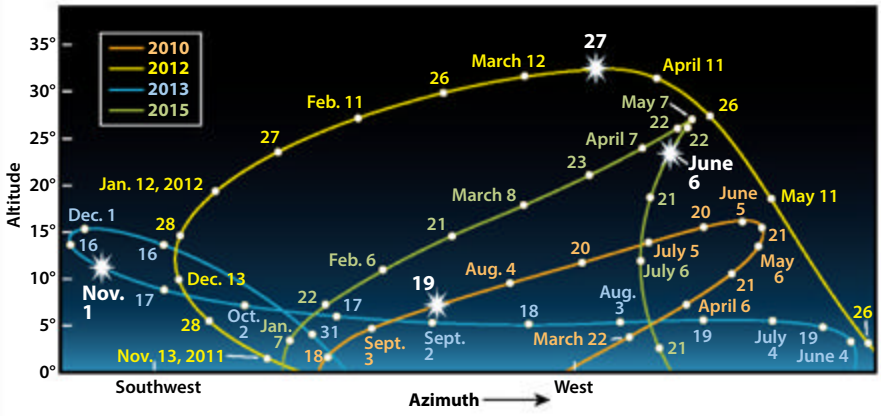
CT scan of a supernova remnant

Astronomers Dan Milisavljevic of the Harvard-Smithsonian Center for Astrophysics and Rob Fesen of Dartmouth College used infrared observations to peek into the hidden heart of supernova remnant Cassiopeia A. They found a Swiss-cheesed interior comprising about a half dozen large bubbles blown by the exploding star 340 years ago. Studying these bubbles can help astronomers understand the complex physics of a stellar explosion. They published their most recent findings in the January 30 issue of the journal *Science*. For more details on their work with Cas A, see their story in *Astronomy*'s October 2014 issue. **— K. H.**

VENUS IN THE EVENING

From 40° north latitude, Venus peaks at an altitude of 27° this May. It appeared some 5° higher in March 2012, its only better performance in the past five years.

FAST FACT



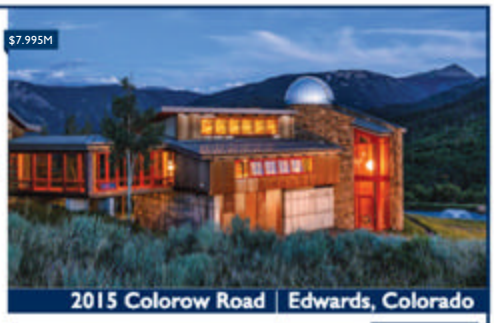
BRILLIANT PLANET. How dazzling is Venus? Even on a bad day, it shines nine times brighter than the night sky's brightest star, Sirius. But Venus stands out even more when it blazes against a dark sky, as it will when it reaches peak altitude in May's evening sky. This chart plots the positions of Venus during its past four apparitions for an observer at 40° north latitude an hour after sunset. Notice that the planet's peak altitude often doesn't coincide with its greatest solar elongation (dates highlighted in white). *ASTRONOMY*: RICHARD TALCOTT AND ROEN KELLY

WorldMags.net

SQUAW CREEK ESTATE

Captivating 6-bedroom, 8-bathroom contemporary mountain estate on 23.81 acres offering majestic views of the Gore Range and Sawatch Range. This fully-automated "smart home" features solar panels, a geothermal pond, professional telescope observatory, indoor tropical greenhouse, and adjacent 10+ acres with building site also available for sale.

Matthew@AscentSIR.com
SquawCreekEstate.com



2015 Colorow Road | Edwards, Colorado

Matthew Blake
Broker Associate
c 970.390.2692

Ascent Sotheby's

Each Office is Independently Owned and Operated. Availability and pricing subject to change.

SCOPE OUT

THE LARGEST SELECTION AT ADORAMA

Get the Best Prices
From the Only Store With
Same Day Shipping Until 8pm



TeleVue
85mm f/7 APO
Refractor Evergreen Kit
$2,089.95

Celestron
Advanced VX 6"
Refractor Telescope
$1,299.00

iOptron
SkyTracker Camera
Mount with Polar Scope
$299.00

SHOP RENT PRINT LEARN TRADE

Search for more value at adorama.com

42 W 18TH ST NYC
800.223.2500
adorama.com

ADORAMA
MORE THAN A CAMERA STORE

From grab-and-go
to observatory-class,
we have a mount for you.
Smooth tracking • Whisper quiet •
Easy set up • Accuracy • Lightweight

iOptron



iEQ30 Pro
#3000E
~~$1448~~
Promo $1299



iEQ45 Pro
#8000E
$1848



CEM60
#7200
+/- 5 arc sec
$2499

CEM60-EC
#7201
0.5 arc sec RMS
$3899

Introducing the new...
Tri-Pier #8034 $598

Astronomics
1.800.422.7876
www.astronomics.com

B&H Photo
1.800.606.6969
www.bhphotovideo.com

High Point Scientific
1.800.266.9590
www.highpointscientific.com

OPT
1.800.483.6287
www.opttelescopes.com

Woodland Hills Telescopes
1.888.427.8766
www.telescopes.net

Ontario Telescope (Canada)
1.905.487.6363
www.ontariotelescope.com

www.iOptron.com
Innovation • Value • Customer Support

WorldMags.net



SECRET**SKY**

BY STEPHEN JAMES O'MEARA

A 12th-century sunspot enigma

Is this feature observation or decoration?



Is this the earliest surviving illustration of sunspots? This carefully executed sketch is a copy of the original illustration. The copyist used a quill pen and executed the drawing on bovid parchment. RANDALL A. ROSENFELD, AFTER JOHN OF WORCESTER

In January 2015, I received an email from Randall A. Rosenfeld, archivist for the Royal Astronomical Society of Canada, asking for help from *Astronomy* readers. The issue deals with a 12th-century rendering of what is now generally accepted as the earliest surviving depiction of sunspots. And you may be able to help verify a key aspect of this stylized drawing.

Interpretation

The drawing exists in a 12th-century manuscript of a Latin chronicle attributed to "John of Worcester," who made the observation December 8, 1128, from England. Of it, he wrote, "… from morning till the time of vespers there appeared as it were two dark balls below the orbit of the Sun. One, which was the larger, in the upper part, and the other, which was smaller, in the lower part."

As Rosenfeld explains in the October 2014 *Journal of the Royal Astronomical Society of Canada*, the two dark balls were not actually beneath the Sun. "The Sun was placed in the realm of objects not subject to change and corruption," he says. "Spots could not mar the solar surface by occurring on it, but they could be sublunary objects in orbits beneath the Sun seen against its surface from the Earth."

If this is the case, then the depictions may be remarkable in that they show a clear distinction between each spot's umbra (the dark inner part) and penumbra (the light outer region) — namely, they appear as black balls surrounded by concentric red circles; each outer circle is stylized.

While we can interpret the colored circles surrounding the black spots as penumbral regions, Rosenfeld says, other alternatives exist: They could be mere decorative features typical of 12th-century iconography, or their representations also could be decorative features that carry observational information.

"The problem is that the visual conventions of the artist are not our visual conventions," Rosenfeld explains, "and the rarity of the image, and the paucity of mid-12th-century solar cartographic legends set us at a disadvantage. The passage of nine centuries is hard to overcome!"

A visual challenge

Rosenfeld wonders if it is possible to clearly detect the difference between penumbral and umbral regions of great sunspots when observing with the naked eye (suitably protected) or by pinhole or other forms of projection. And thus he is asking us to help.

Today, people often see naked-eye sunspots through safe optical filters. Occasionally, a person can observe a sunspot when fog, haze, or other atmospheric contaminants greatly reduce our star's glare, particularly near sunset.

In a 1992 *Quarterly Journal of the Royal Astronomical Society*, H. U. Keller (Zurich Observatory) and T. K. Friedli (Sun Observer Group of Swiss Astronomical Society) reported on sunspot sightings based on observations of naked-eye spots from 20 observers.

They determined that an average eye can see a sunspot with a penumbral diameter of at least 41 arcseconds and an umbral diameter of at least 15 arcseconds. However, the authors also say, "The observers themselves were, of course, not able to distinguish between umbra and penumbra."

But the absence of evidence is not evidence of absence. How many of those same observers would have seen penumbral shadings had they been asked to look? Also, were any of the observed spots parts of exceedingly large groups?

Rosenfeld considers the possibility of detecting penumbrae via pinhole projection because pinhole cameras in medieval Europe survived from the century after John of Worcester and from earlier in the Middle East. "There may very well be a medieval account which may suggest that solar surface detail (a very prominent sunspot) was detectable by means of a pinhole camera," Rosenfeld says.

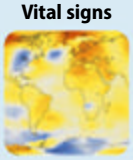
Rosenfeld is eager to hear what you have to report based on your observations and especially welcomes what you see when you use pinhole projection. You can contact Rosenfeld at rosenfel@chass.utoronto.ca, and be sure to copy me at sjomeara31@gmail.com.

COSMIC WORLD

A look at the best and the worst that astronomy and space science have to offer. **by Eric Betz**

Cold as space — Supernova hot

Vital signs



NASA's suite of climate spacecraft verify 2014 as the hottest year since temperature records began in 1880, ever so slowly lowering the list of known habitable Earth-like planets to less than one.

Child labor



Worms with freshly severed heads and tails are sent to the space station for astronauts to study organ regeneration in orbit. Somewhere, NASA is staffing a room full of 10-year-old boys.

Entropy happens



Hubble spots a cosmic smiley face. The eyes are two bright orange galaxies and light-bending gravity in the galaxy cluster forms the smile, proving that E.T. exists and, unlike that creepy face on Mars, wants us to be happy.

Proud pooches



Astronaut Leland Melvin, a former NFL player, chemist, and engineer, gets online *awws* for sneaking his rescue dogs into his NASA portrait. Those may be the only pups with an accurate view of their owner's awesomeness.

NASA GODDARD SPACE FLIGHT CENTER (VITAL SIGNS); NASA (CHILD LABOR, PROUD POOCHES); NASA/ESA. ACKNOWLEDGEMENT: JUDY SCHMIDT (ENTROPY HAPPENS)

BROWSE THE "SECRET SKY" ARCHIVE AT **www.Astronomy.com/OMeara.**

WorldMags.net

2015 SUMMER SWEEPSTAKES

More than $2,200 in prizes



GRAND PRIZE

NexStar Evolution 6 WiFi Telescope

Celestron's signature telescopes reach a new level with NexStar Evolution 6, the first Schmidt-Cassegrain telescope with a built-in Wi-Fi connection and integrated long-life lithium battery. Leave your hand control behind and slew to all the best celestial objects with a tap of your smartphone or tablet.

Retail value: $1,199.00



1st

COSMOS 90GT WiFi Telescope

Interact with the night sky in a whole new way using this Wi-Fi-enabled 3.5-inch refracting telescope and your smartphone or tablet! Celestron's new COSMOS Celestron Navigator mobile app replaces the traditional telescope hand control for a 100% wireless experience.

Retail value: $399.95



2nd

SkyMaster Pro 15x70 Binoculars

SkyMaster Pro binoculars are the ideal choice for amateur astronomers. With large objective lenses, BaK-4 prisms, and fully multicoated optics utilizing Celestron's proprietary XLT coating technology, the view through a SkyMaster Pro is second to none at its price point.

Retail value: $199.95



3rd

COSMOS FirstScope

This Dobsonian-style telescope featuring a 3-inch reflector optical tube is an ideal entry-level astronomical telescope. This special edition of Celestron's bestselling FirstScope offers several upgrades over the original, including two Kellner eyepieces and a StarPointer red dot finder scope.

Retail value: $69.95



4th

1-Year *Astronomy* Subscription

(10 awarded)

Receive 12 exciting issues of knowledgeable science reporting, insights from top experts, monthly sky charts, spectacular celestial photography, informative equipment reviews, and more. Plus, enjoy all the subscriber-only benefits at Astronomy.com.

Retail value: $42.95 each

ENTER TODAY!

Enter online at Astronomy.com/Sweeps
Or fill out and mail the attached card.

See page 69 for Official Sweepstakes rules.

HURRY!

Entries must be postmarked by July 24, 2015.

Sponsored by:

CELESTRON Astronomy

P25279

WorldMags

ASTRO**CONFIDENTIAL** BY KARRI FERRON

WHAT HAVE WE DISCOVERED ABOUT INTERMEDIATE-MASS BLACK HOLES?

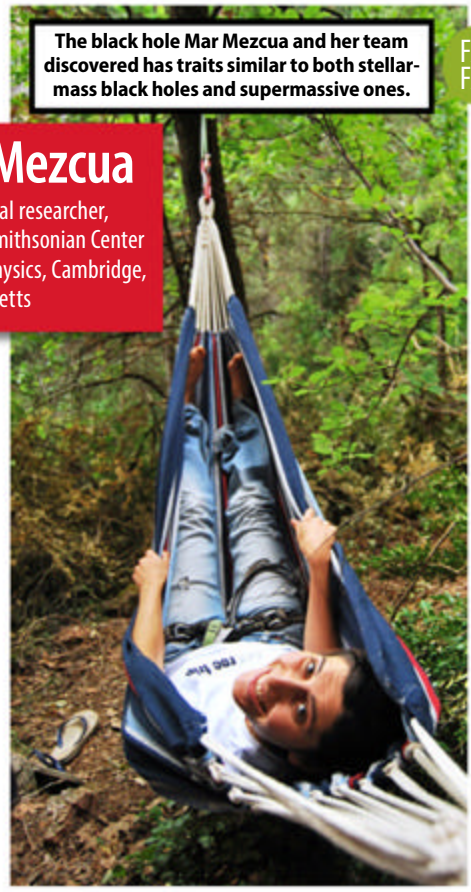
Astronomers have found supermassive black holes weighing a billion times more than the Sun at the center of galaxies when the universe was only 800 million years old. We know that the material feeding these starving black holes heats up and emits X-rays, while highly energetic particles emitting radio waves are ejected from the innermost regions of the black hole in the form of collimated jets. However, how these monsters have reached their mass and become so powerful already in the early universe still puzzles astronomers. One possibility is that they grow from seed black holes of lower mass, so-called intermediate-mass black holes (IMBHs), weighing a thousand times more than the Sun but a thousand times less than supermassive black holes.

IMBHs have been long sought as the missing link between stellar-mass black holes, formed from the death of a star, and supermassive black holes; nevertheless, observational evidence for their existence remains scant. Thanks to combined X-ray and radio observations, we have discovered an IMBH of 50,000 solar masses wandering in the arm of a spiral galaxy. The galaxy seems to have undergone a merger with another galaxy of lower mass, suggesting that the IMBH is the nucleus of the dwarf galaxy whose body has been stripped off during the collision. The IMBH has a radio jet as powerful as those observed in supermassive black holes, which are able to clear out a cavity and suppress star formation.

We have thus learned that the spiral arms of galaxies, especially those undergoing a merger with a low-mass galaxy, are great places to search for the seed IMBHs from which supermassive black holes may form. Ultimately, these IMBHs can have a large impact on their surroundings, as supermassive black holes do, which has strong implications for studies of supermassive black hole growth.

Mar Mezcua
Postdoctoral researcher, Harvard-Smithsonian Center for Astrophysics, Cambridge, Massachusetts

The black hole Mar Mezcua and her team discovered has traits similar to both stellar-mass black holes and supermassive ones. FAST FACT



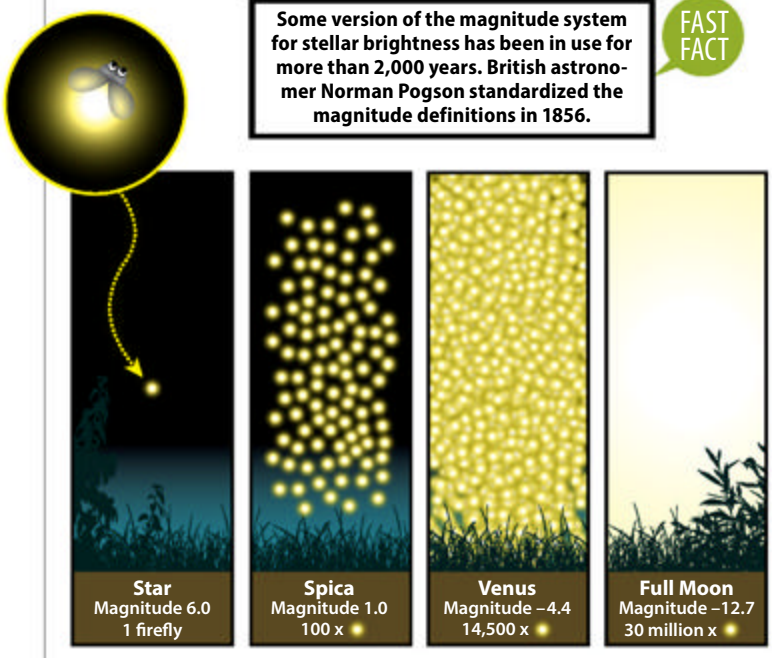
COURTESY MAR MEZCUA

ASTRO**NEWS**

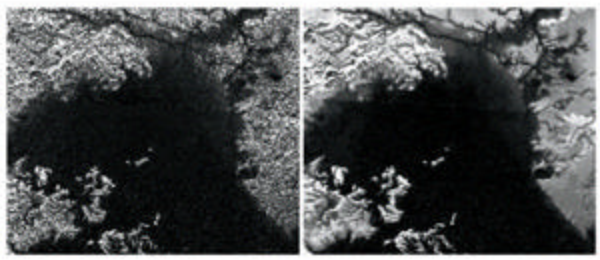
SATELLITE EXPLODES. A 20-year-old U.S. military weather forecasting satellite exploded for unknown reasons in early February, breaking into 43 pieces that the Air Force is now tracking, the website SpaceNews.com confirmed.

STAR LIGHT, HOW BRIGHT?

Some version of the magnitude system for stellar brightness has been in use for more than 2,000 years. British astronomer Norman Pogson standardized the magnitude definitions in 1856. FAST FACT



FIREFLY. Magnitudes can be difficult to understand. An increase of 1 magnitude means a 2.5118865-fold increase in brightness. This chart shows a magnitude 6.0 star represented by a single firefly. A star 5 magnitudes brighter, like Spica, would be 100 times as luminous. Much brighter objects, like Venus and the Full Moon, reflect far more light than any star produces because they lie closer. *ASTRONOMY:* MICHAEL E. BAKICH AND ROEN KELLY



"DESPECKLED" DATA. This before-and-after image shows Cassini radar data of Titan's surface with (right) and without an algorithm applied to modify electronic noise. NASA/JPL-CALTECH/ASI

Titan comes in clearer than ever

Due to Titan's thick atmosphere, scientists have used the Cassini spacecraft's radar instrument to reveal the saturnian moon's surface features. The resulting images have provided insights into the large satellite's sand dunes and methane lakes, but they still hide small-scale features because with radar comes image "noise."

But thanks to a new image-processing algorithm, some views are coming in clearer than ever, as NASA announced February 11. Antoine Lucas, a planetary geophysicist at CEA-Saclay in France who worked with the Cassini radar team as a postdoc, looked to the mathematics community for models to reduce the grainy appearance and came up with "despeckling," which successfully modifies the noise without compromising the data.

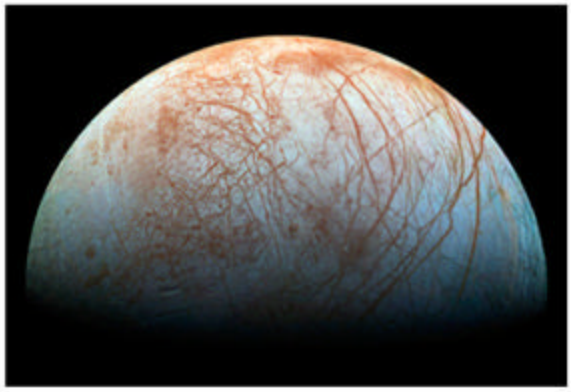
The clearer images will provide Cassini scientists with fresh views of surface features, but "despeckling" won't be used on all images just yet. "It takes a lot of computation, and at the moment quite a bit of 'fine-tuning' to get the best results with each new image," says radar team member Randy Kirk of the U.S. Geological Survey, "so for now we'll likely be despeckling only the most important — or most puzzling — images." — **K. F.**

WorldMags.net

GOD PARTICLE AFTER ALL? Physicists studying the Higgs boson say its field could have created asymmetries that kept antiparticles from annihilating all the particles in the early universe, allowing matter to form.

SPACE SCIENCE UPDATE

NASA GREEN-LIGHTS EUROPA FLYBY MISSION



BRINY DEEP. A trip to Europa might confirm water plumes seen by the Hubble Space Telescope and explain the moon's reddish "chaos terrain," which some interpret as materials — possibly organics — mixing from beneath the surface. NASA/JPL-CALTECH/SETI INSTITUTE

At long last, NASA is poised to explore a world heralded as the most habitable non-Earth in the solar system. The White House and Congress have approved funds to develop the Europa Clipper, which could take off for Jupiter as soon as 2022. And unlike past plans to study the moon, scientists say this mission appears likely to stick.

"NASA has been very vocal that we're going to do a Europa mission," says Europa Clipper pre-project manager Barry Goldstein of NASA's Jet Propulsion Laboratory (JPL). "We're very confident that we should achieve formal project status before the end of the fiscal year."

The mission passed a critical "gateway" concept review in September, and in February, Congress slated more than $100 million for development, a large increase over the president's request, which itself formalized crucial executive branch support.

Astronomers first dreamed of this trip when Voyager 2 saw evidence of Europa's icy shell in 1979. And when Galileo became the first spacecraft to circle Jupiter in 1995, its eight-year, 35-orbit mission chronicled a dynamic world that ignited the imaginations of scientists and the public alike. Europa is now widely expected — but yet to be confirmed — to have a global subsurface ocean, home to more liquid water than Earth.

And in decadal surveys since Galileo, the planetary science community has agreed on the importance of a mission to orbit Europa. But that hasn't translated into a spacecraft.

Europa's orbit sits some 400,000 miles (644,000 kilometers) from the largest planet in the solar system — just over twice as far away as the Moon is from Earth. Any ship placed that close to Jupiter needs radiation shielding to withstand high-energy electrons traveling at near light-speed. The price tag for such an orbiter would approach $5 billion, likely an impossible sum in the current fiscal environment.

NASA asked scientists for alternatives, and they found several, including one that seizes on something the agency had already mastered: studying the moons of Saturn.

JPL's Brent Buffington helped calculate a spacecraft trajectory for Cassini's extended Saturn mission. Its last seven years and 155 orbits use scant fuel to make daredevil flybys, exploring Enceladus' hydrothermal vents and Titan's rainfall.

Buffington worked the same magic on the Europa flyby spacecraft design. His trajectories proved Clipper could image the entire moon and come in cheaper with better science.

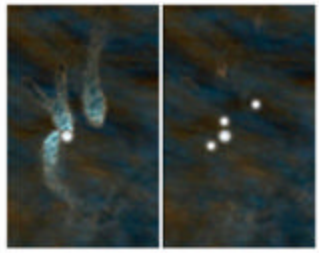
The moon was divided into 14 regions, which would each need imaging overlap for a global map. Some regions of Europa still have only been seen by Voyager, and one single 6-meter-per-pixel image holds the high-resolution record. By zipping within 60 miles (100km) during at least 45 flybys, NASA will nab pictures comparable to the current Mars Reconnaissance Orbiter's 0.5-meter-per-pixel resolution.

"We have an architecture that is much better tuned for a mission of discovery," Goldstein says. "We're able to observe Europa from afar, and if we see a plume while we're far out, we can adjust our flyby."

So far, a launch vehicle isn't set, but Goldstein's team hopes to see it fly on the massive Space Launch System, which could go straight to Jupiter without the gravitational assistance of flybys. That would shave five years off the trip and possibly allow spare room for more scientific instruments, including CubeSats.

Confirming Europa's plumes picked up by the Hubble Space Telescope will be a key goal. If the moon has volcanism like its neighbor Io, seafloor vents similar to Earth's could create chemical reductants. While on the surface, radiation would separate hydrogen and oxygen from the water, creating oxidants. Mixing the two might give the chemical energy needed as a battery for life.

"We're learning more about these icy bodies — how they interact gravitationally and how they can create environments," says Europa Clipper pre-project deputy project scientist David Senske of JPL. "Europa is really much larger; it's the size of our Moon and has the ability to sustain a liquid for a good chunk of solar system history. The thought is if these ingredients are there, maybe some form of life has evolved." **— E. B.**



SIBLING STARS. An artist illustrates the stellar nursery in Barnard 5 as it appears now (left) and how it will appear after the family of stars turns on, but before one unlucky member is ejected. BILL SAXTON/NRAO/AUI/NSF

Lessons in multiple star formation

Astronomers are learning important lessons in how multiple star systems — the most common type — form. Scientists used radio data from the Very Large Array in New Mexico and the Green Bank Telescope in West Virginia to peer inside a clump of gas called Barnard 5, where one protostar was already known to exist. They found fragmenting filaments of gas, all gravitationally bound to each other, in the process of collapsing down to form three additional stars. While it's easy to find mature multistar systems, this is the first time such a stellar nursery has been observed so clearly on that path. Based on the gas clumps' dynamics, the astronomers predict that one of the stars will eventually be ejected, leaving behind a triple star system. The international research team published their findings in *Nature* on February 12.

On the same day, scientists at the Harvard-Smithsonian Center for Astrophysics announced that a less common type of system also has been spotted in the making: an extreme mass-ratio binary, where one star in a pair is significantly heftier than its partner. The astronomers spotted 18 systems in the fleeting situation where the more massive star (which contracts faster because of its greater gravitational pull) has "turned on" while its lighter partner is still in the process of collapsing. The smaller protostar is puffy and reflects light from its mature partner star, revealing phases from certain viewing angles. This rare situation lets astronomers observe a critical stage in star formation, yielding valuable details about how stars are born. **— K. H.**

WorldMags.net

REGISTER TODAY! Go to www.Astronomy.com/register for access to bonus articles, photos, videos, and more.

50 Weirdest Objects

Cosmic oddities with Bob Berman

Whether relatively close to home or billions of light-years from us, the cosmos is filled with weird and wacky wonders. After all, as Contributing Editor Bob Berman aptly demonstrates each month in *Astronomy*, we really do live in a strange universe. And now magazine subscribers can follow Berman's countdown of the 50 strangest and most fascinating oddities he's come to know over the years. Each week at **www.Astronomy.com/50weirdest**, find a new object that Berman believes should be inducted into the "Cosmic Hall of Weird," starting at No. 50 and counting down to No. 1 by the end of the year. What will be the strangest?



Throughout the year, magazine subscribers will get to tour everything from the coldest place in space and some planetary wannabes to invisible particles and dark galaxies. Be sure to follow *Astronomy* on Facebook and Twitter for updates on when we publish each new mini-guide (along with lots of other fun stuff), and bookmark **www.Astronomy.com/50weirdest** to take part in the year of the weird. But remember, the online version of Bob Berman's *50 Weirdest Objects in the Cosmos* is only available to magazine subscribers. Join the countdown and receive in-depth articles and tips delivered directly to your door as well as other great online features by subscribing to *Astronomy*. Just visit **www.Astronomy.com/subscribe**.

OBSERVING TOOLS

Observing Basics video series

Senior Editor Michael E. Bakich has logged tens of thousands of hours at the eyepiece, and with his *Observing Basics* video series, he's sharing tips with you. In each episode, Bakich tackles a topic based on frequent questions he receives from readers, covering everything from choosing the right equipment to tips for dealing with dew and how to prevent eye fatigue and improve dark adaption. Beginners and advanced observers alike, check out all the episodes at **www.Astronomy.com/observingbasics**.

COMMUNITY

Reader Photo Gallery

Browse thousands of beautiful astroimages like this one of Comet Lovejoy (C/2014 Q2) by John Vermette. Submit your own at **www.Astronomy.com/readergallery**.



Dave's Universe blog

Astronomy Editor David J. Eicher shares amazing astrophotos, takes you along on trips, provides info on his favorite topics or a recent scientific pet peeve, and much more at **www.Astronomy.com/davesuniverse**.

FOLLOW *ASTRONOMY* www.twitter.com/AstronomyMag www.facebook.com/AstronomyMagazine plus.google.com/+astronomymagazine









WorldMags.net



Why Are Tele Vue Products So Good? Because We Aim to Please!

For over 30-years we've created eyepieces and telescopes focusing on a singular target; deliver a customer experience "...even better than you imagined." Tele Vue products provide an observing experience as exquisite in performance as it is enjoyable and effortless.

Pneumatic Air-Chair

NP101 f/5.4 APO refractor with 110° Ethos-SX eyepiece shown on Gibraltar Mount with Sky Tour digital setting circles.

And how do we score with our valued customers? Judging by superlatives like: "truly amazing, awesome, beautiful, work of art, exceeded expectations by a mile, best quality available, WOW, uncompromised, gorgeous" etc., BULLSEYE! See these warranty card superlatives in context at TeleVue.com/comments.

32 Elkay Drive, Chester, New York 10918 845.469.4551 www.TeleVue.com

Tele Vue

KITT PEAK NATIONAL OBSERVATORY

Tucson, Arizona

Astrophotography Workshops:

Beginners
October 16-17

Advanced
November 6-7

- Daily Guided Tours
- Public Programs for Amateur Astronomers
- Advanced Observing Program
- Image Queue Data Gathering

Start your journey by visiting
www.noao.edu

Vixen NA140SS Instant $400 Rebate!



Reg Price ~~$1999~~
Less Rebate - $ 400
Your Price $1599
Available through July30 while supplies last

The Quad Element Neo Achromatic Design of the NA140SS incorporates a two element objective lens and an additional optical correction with 2 elements, including a field flattener, in the drawtube . This combination results in edge to edge sharpness, bright images, and ED like color correction. The NA140S (f/5.7) is 100% Made in Japan and covered by a 5 Year Warranty.

When Quality Matters, Vixen Mounts and Scopes are the Clear Choice.

vixenoptics.com (949) 429-6363

Vixen Optics

WorldMags.net

The only person to fly to the Moon twice but never trod its surface has some amazing stories to tell. **by Richard Talcott**

Jim Lovell IN HIS OWN WORDS

In today's celebrity-obsessed culture, the word *hero* gets bandied about far too often. But what other term would you use to describe astronaut James Lovell? A veteran of four spaceflights, his accomplishments paved the way for the first Moon landing and helped define NASA's can-do attitude.

In December 1965, he and Frank Borman flew on Gemini 7, where they performed the first rendezvous with another manned spacecraft (Gemini 6A). In November 1966, he teamed with Buzz Aldrin on Gemini 12, the final mission of the Gemini program. But Lovell's main claim to fame came during the subsequent Apollo program. He served as the command module pilot on Apollo 8 — the first manned spacecraft to leave Earth's gravity and orbit the Moon. And he was commander on Apollo 13, which suffered a crippling explosion on its way to the Moon and barely made it safely back to Earth.

Recently, *Astronomy* Editor David J. Eicher and I interviewed Captain Lovell about his Apollo missions at Lovell's of Lake Forest, his restaurant in suburban Chicago. At 86, he remains every bit as sharp and entertaining as he was during his NASA days, when astronauts were this country's true heroes.



ASTRONOMY: DAVID J. EICHER

ASTRONOMY: **Thanks, Captain Lovell, we certainly appreciate your being here today and having this interview with us. Apollo 8 was the first of many missions that went to the Moon, and you did a lot of things for the first time. Did it help with your comfort level to have Frank Borman with you, since you had flown with him earlier?**

LOVELL: Yes, Frank and I flew for two weeks on Gemini 7, in a small little container called the Gemini. Some people call it two weeks in the men's room. I was particularly happy to be on [Apollo 8] because it was the first time that we'd navigated the entire 240,000 miles [385,000 kilometers] to the Moon. When I was with Charles Lindbergh on the beach watching Apollo 11 lift off, he said, "You know, Apollo 8 was almost like my flight across the Atlantic [because of] the long distance — all Apollo 11 had to do was land."

ASTRONOMY: **Your Apollo mission originally was planned to test the lunar module in Earth orbit, but delays in the lunar module program changed those plans. How lucky did you feel that the mission order changed so that you were able to be on the first flight to the Moon?**

LOVELL: Well, I was pretty happy. I had already been up twice, and this would have been three times to go around again doing about the same thing. I was the command module pilot, so I would have been in the command module, not in the lunar module. As a matter of fact, I started out being on the Apollo 11 flight and Mike Collins was on Apollo 8. He had a neck injury that had to be repaired before he could fly, so I replaced Mike on Apollo 8, and he took my spot on Apollo 11.

ASTRONOMY: **I take it you weren't necessarily disappointed with that?**

LOVELL: No, that's exactly right. Because on Apollo 11, I would have been the command module pilot, orbiting again. Being the first to go to the Moon on Apollo 8, that was something I really enjoyed.

ASTRONOMY: **What were your thoughts when you became the first people to leave Earth's gravity behind?**

LOVELL: It was a unique feeling in many respects. First of all, we were like three school kids looking down on the farside of the Moon when we first went around there. The ground was tracking us at this time, and they said that at such and such

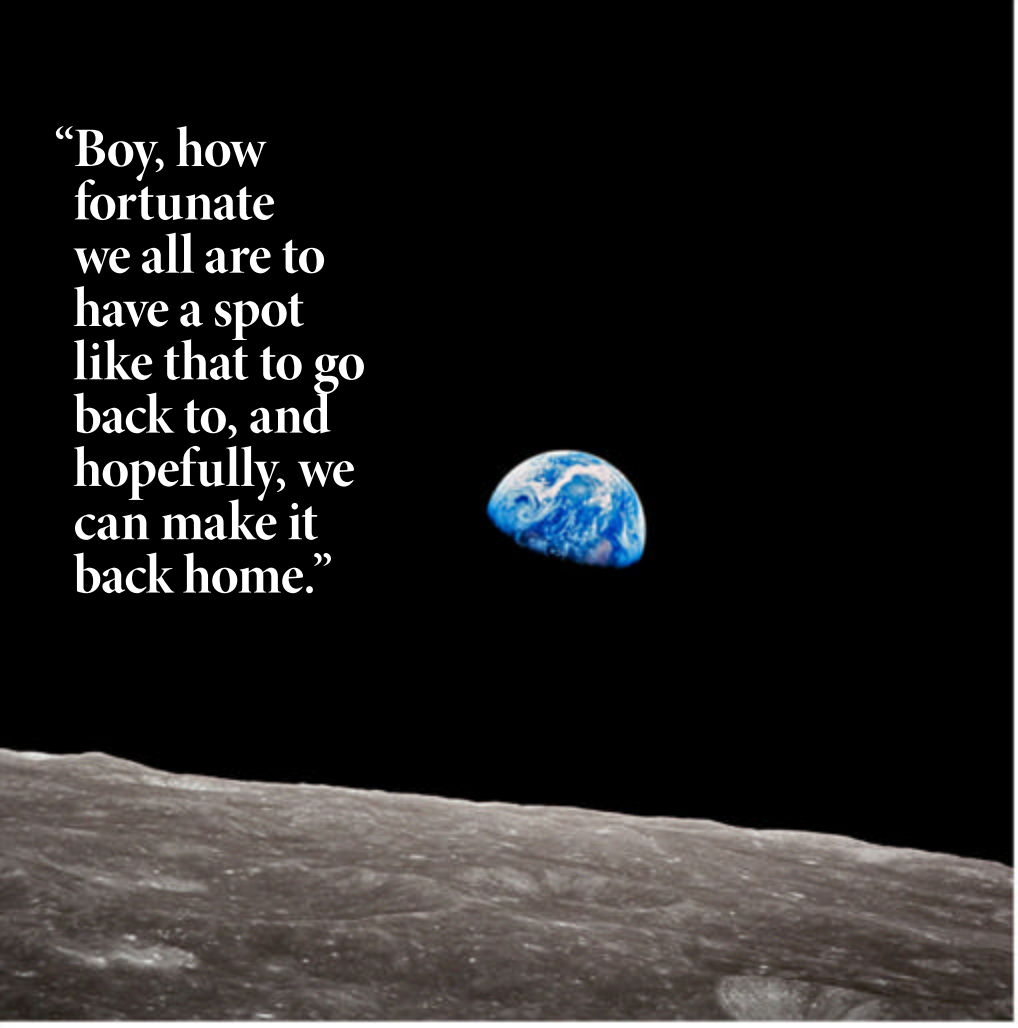
Senior Editor **Richard Talcott** *watched with rapt attention as Jim Lovell twice journeyed to the Moon and back during the Apollo program.*

WorldMags.net



The crew of Apollo 8 — (left to right) Jim Lovell, Bill Anders, and Frank Borman — pose on a simulator at Kennedy Space Center just a month before they took off for the Moon. NASA

WorldMags.net



Earth rises over the Moon's limb as Apollo 8 comes out from behind the Moon on its fourth orbit. The lunar horizon lay approximately 485 miles (780 kilometers) from the spacecraft when Bill Anders captured this iconic scene. NASA

a time, down to the second, you'll lose communication with us. By gosh, right on the second, we whipped around the far-side and lost communication. You know the Moon has three different shades. In sunlight, it's quite bright; in earthshine, it looks like snow outside at nighttime here on Earth; and then there's the part that has no earthshine, no sunshine — you don't see a thing. And that's the only time when all the stars came out.

***ASTRONOMY*: How were your preparations for Apollo 8? Did they prepare you for what you actually saw at the Moon, or was it totally different from what you were expecting?**

LOVELL: Well, when we got word that we weren't going to do Earth orbit on Apollo 8 but go to the Moon, we had to change a lot of things — navigation was the big thing. The training was very good; there was nothing, I would say, that was a complete surprise to us.

The big surprise is the Earth — it's not a surprise that we thought we're going to see something else — but just suddenly looking at it and seeing it as a small body that you can completely hide behind your thumb. You're only 240,000 miles away, but everything that you have ever known is behind your thumb — all the history of the Earth and all the people you knew and all the problems. It is merely a small body that's orbiting a rather normal star, and it just happens to be at the proper distance with proper mass to support life.

And then I thought how insignificant we really all are. The Sun itself is tucked away in the outer edge of a galaxy called the Milky Way, and that's only one of millions of galaxies in the universe. And here's this little body sitting out there 240,000 miles away, and I thought, "Boy, how fortunate we all are to have a spot like that to go back to, and hopefully, we can make it back home."

***ASTRONOMY*: When you read from the book of Genesis on Christmas Eve, was that a joint decision among all three of you, or did one of you come up with that idea?**

LOVELL: That's kind of interesting. When we were planning our trajectory, all of a sudden it dawned on us that the day we were shooting to take off, on the 21st of December, we would be orbiting the Moon on Christmas Eve. We decided, gee, it's going to be Christmas, what can we say? We've got to think about something to say. So we thought, well how about changing the words to "The Night Before Christmas"? That didn't sound too good. Or how about "Jingle Bells"? No, that was even worse. So we were at an impasse.

We knew a friend who said, "I know a newspaper reporter, and they usually have a gift of gab about writing things like this. I'll ask him." The story I got was that he spent one night trying to figure out what these three people should say. Around midnight, his wife came down the stairs and said, "What are you doing?" And he told her the story that he was writing this thing for the Apollo 8 crew, but he hadn't really come up with anything yet. And she said, "That's simple — why don't they read from the Old Testament, the first 10 verses of Genesis? I mean, it's an emotional time, sort of a holy time, but the first 10 verses of Genesis is the structure of most of the world's religions." So that's what we did. Wrote it down and put it on fireproof paper, and it was put in the back of the flight manual. That original flight manual and those words are now down at the Adler Planetarium [in Chicago].

***ASTRONOMY*: When you were on the farside of the Moon and getting ready to come back, did you have any concerns about the rocket firing?**

LOVELL: I don't think anyone who makes these Apollo flights thinks about that rocket not firing. Of course, we were the first ones there. On the ninth orbit, we did Genesis and things like that and talked about the Moon. But on the 10th one, we wanted to make sure everything was ready. We called back [to Houston and asked for] some good words about what they thought we should put in the computer, exactly when we should fire the rocket, and the whole thing. And when we were on the farside, Mission Control never knew if it fired or didn't fire until we got around to the nearside. Of course, if it didn't fire, we'd still be in lunar orbit. It fired absolutely perfectly, right where it should. And I said to Mission Control: "Houston, please be informed — there is a Santa Claus."

***ASTRONOMY*: You mentioned a little bit earlier about seeing Earth rise as you were going around the Moon. Did you have any idea after you got back how iconic that image would become and that it's been called one of the great images in the history of mankind?**

WorldMags.net



Jim Lovell poses for his formal Apollo 13 portrait four months before the April 1970 mission. The mission's destination target — the lunar crater Fra Mauro — sits near the center of the Moon globe. NASA

LOVELL: When the Earth drifted over to my window and I looked at it — Bill [Anders] was the photographer — and saw the composition of the Earth with respect to the lunar horizon, I said, "Bill, this is it. This is the picture." He had a telephoto lens on the camera, so that brought the Earth closer, where it was more pronounced and made it actually a much better composition, I think. We took lots of pictures, and we didn't know what picture NASA would actually release — whether the pictures of the Moon on the farside or the Earth in various places. It turns out that ["Earthrise"] was a great picture.

***ASTRONOMY*: Now we'll switch gears and discuss your next mission. Could you talk about how the objectives of Apollo 13 differed from those of Apollo 11?**

LOVELL: Apollo 13 was actually going to be the first scientific Apollo flight. If you remember, there was a great space race between the Russians and ourselves. It started out in 1961 when Kennedy said we'd put a man on the Moon. This was a technical challenge, not so much of a scientific expedition. So 11 was successful. And just to prove that we could do it, because there were a lot of people in this country after Apollo 11 landed that said we faked it in West Texas someplace, we did Apollo 12. And it was successful — they landed within walking distance of the Surveyor [3] spacecraft. So these were all really to prove the technology of going to the Moon and coming back.

By the time Apollo 13 came around, we realized that we better start looking at getting the science in the Apollo program. We were designated to land around a crater called Fra Mauro because [lunar scientists] thought that maybe there's ejecta [there that was dug out by big meteorite impacts]. We did a lot of geology fieldwork, and, if you look at the insignia of Apollo 13, it says "Ex Luna, Scientia" [From the Moon, knowledge] — that was the whole point of that mission.

***ASTRONOMY*: Can you describe the liftoff of Apollo 13, and how did you feel heading to the Moon for a second time?**

LOVELL: I was a lot more comfortable for the liftoff on 13. I had two rookies with me; this was their first time. Occasionally, they would look at me, and I would tell them what that noise was — when the valves opened up and the fuel started running down toward the main engine, you could hear that rumble. I was very comfortable on 13 because I knew what to expect, up until the second stage engine shut down [about two minutes early]. We wondered whether we had enough fuel to go all the way to the Moon, but we did.

***ASTRONOMY*: This was your second trip to the Moon, your fourth flight into space overall. Were you used to the sights, the sounds, the smells, and how the stars appeared? Was it a familiar experience for you?**

LOVELL: Yeah, to me, it was very familiar. They all came back, even the smells. There was no problem. Of course, when we got off the free-return course [a midcourse correction required to change the trajectory for the upcoming lunar landing], that kind of worried us a little bit because that put us in a position whereby

THE CASE FOR MOUNT MARILYN

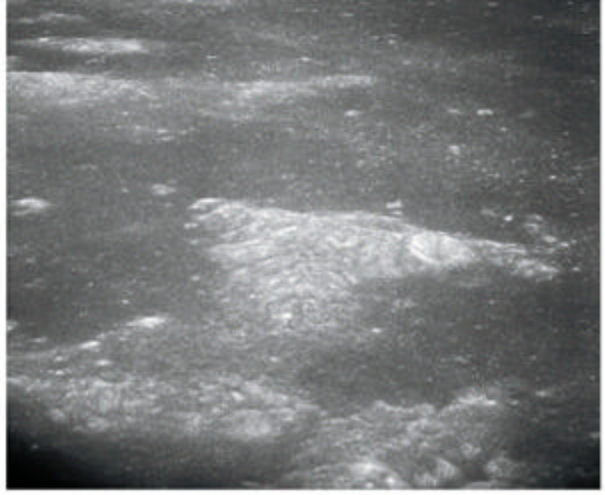
***ASTRONOMY*: Jim, if you would, tell us a little bit about the intriguing story of Mount Marilyn.**

LOVELL: When we were planning to go to the Moon on Apollo 8, we were looking at lunar charts. And we saw some of the nearside features — the area that we were going to fly over. And there was a little triangular mountain down there just on the shore of the Sea of Tranquillity, and I looked at it and I looked it up to see if it had a name to it. It had no name to it. The crater [abutting it] had a name; it was called Secchi Theta. But the mountain itself had no name. And so I said to Bill and to Frank: "I think I'm going to name this Mount Marilyn, [after my wife]." And we can use it as sort of an initial point [a landmark that future crews could use as they began their final approaches] for our flight to see if it would be good for Apollo 10 and Apollo 11. And on the flight, we found out that it was very good. We saw it down there and mentioned it on Apollo 8. When we got back, we talked to the crews that were going to be on Apollo 10 and 11, [which would be following] the same trajectory, and they said "Yes, that's a good spot. We'll use that as an initial point."

So it's in the [communications on] both of their flights, and then we sort of forgot about it for a long time. I kept referencing it sometimes, and Mount Marilyn got into the literature a little bit. It was in the movie *Apollo 13*. And finally, I thought to myself, we've made six landings on the nearside of the Moon, but there's nothing there to look at to represent those landings. Now [more recently], we have good photography on the farside, so the IAU [the International Astronomical Union — the official arbiter in naming solar system features] made a lot of new crater names of the people who were in the program. But on the nearside, after six landings, there's nothing. So why don't we officially look at Mount Marilyn as the one thing that we can see from the Earth with a regular old telescope as the initial point for the first landing? I tried to get a little program going, and there were lots of people that were very interested. But the IAU, of course, says "No."

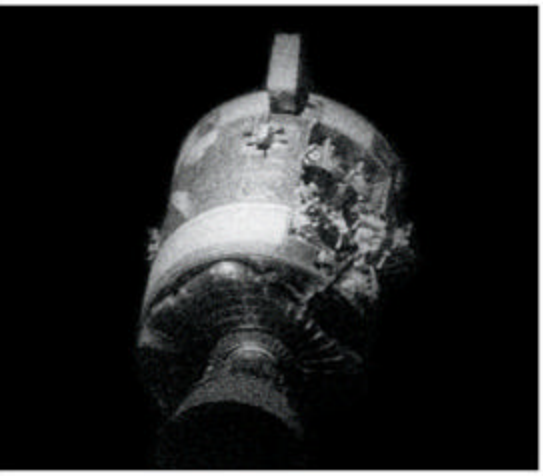
***ASTRONOMY*: This name has been used systematically for decades now. It's high time to make it official.**

LOVELL: I hope so, and I hope the IAU reconsiders our request to do something for this thing that represents all the people and our efforts to land on the Moon.



The triangular-shaped "Mount Marilyn" served as a point of reference for astronauts on both Apollo 10 and 11. The Apollo 10 crew snapped this oblique view during its May 1969 mission. NASA

WorldMags.net



An oxygen tank exploded during Apollo 13's flight to the Moon and left the craft crippled. The blast blew away an entire panel on the service module, seen here after the astronauts jettisoned the module just before reentry. NASA

we wouldn't be able to get back to a safe landing on the Earth. But we had to do that to get the Sun in the proper position [for lunar orbit] so we could see the shadows of the rocks and boulders on the lunar surface. Because there is no atmosphere on the Moon, if you look straight down at noontime, it all washes out. You don't see anything. You had to have shadows to get a good perspective — a 3-D picture of where you're going.

***ASTRONOMY*: Can you describe the moment that you heard, in your words, a hiss-bang explosion?**
LOVELL: Well, I was wondering what it was. There was an occasion beforehand where Fred [Haise] would turn the "repress valve" all the time, and it had a bang to it. I thought he was just trying to scare us, but he didn't do that. I wasn't too concerned at that time. I saw that we had an electrical problem at first, and I thought it might have been one of the batteries that we heard through the lunar module. But it turned out when we saw the oxygen escaping, that told us we were in serious trouble.

***ASTRONOMY*: How did you hold your composure in such an extraordinary and unprecedented moment of crisis?**
LOVELL: Well, if you want to get in this business, you better be optimistic. I was a test pilot, and I had problems with airplanes before where I had to suddenly figure out what to do. I wasn't too sure at the time of the explosion that we were in danger until we saw the oxygen leaking. Then, we just had to figure out what to do. I thought our chances were probably pretty low at that time of getting back because we didn't know exactly what the problem was back there — did we lose two oxygen tanks or did we just lose one? When we saw that two fuel cells had died and, of course, when we lost the oxygen, we then knew the other fuel cell was going to die because it uses oxygen and hydrogen to produce electricity and water.

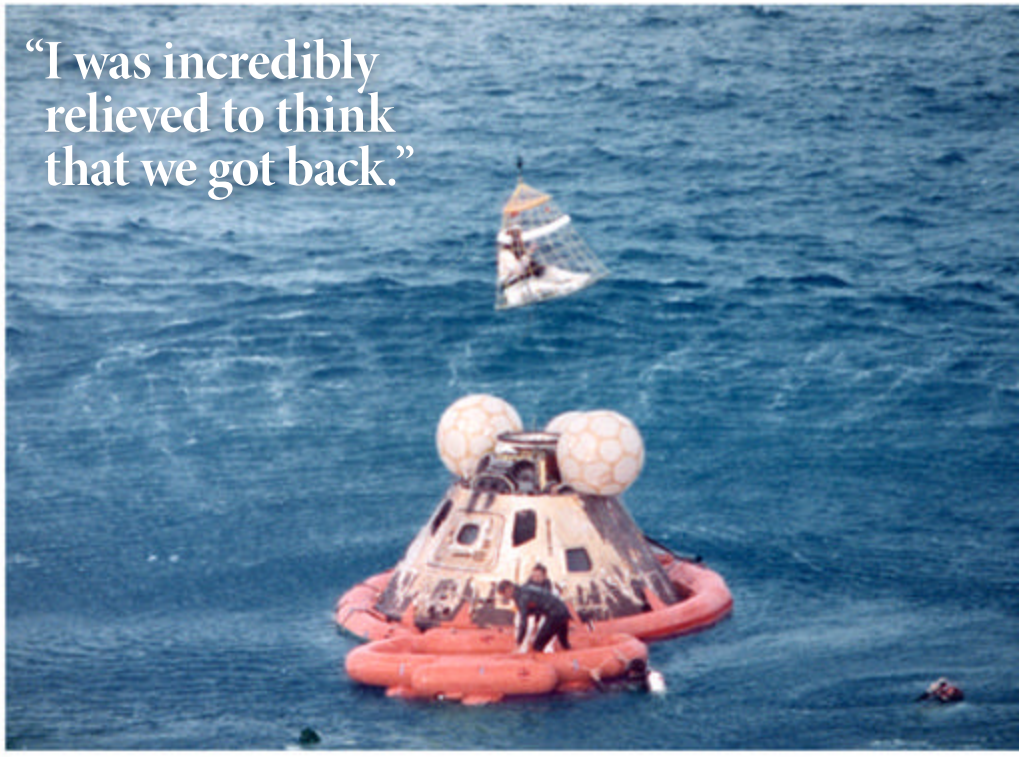
That put us in a very tight spot. We were 90 hours and about 200,000 miles from home. And our lunar module, which was eventually used as a lifeboat to get home, was designed to only last 45 hours and support two people. Counting the crew — there were three people there.

***ASTRONOMY*: What was it like using the lunar module for propulsion and maneuvering? The craft was in an unprecedentedly tricky operation, was it not?**
LOVELL: The lunar module had never been used [for this purpose]. It had been studied to use this technique but never had really been simulated. Of course, we're happy we had it. It had the landing engine on it, had its own fuel, its own oxygen — to last 45 hours and to support two people. The one thing we ran into was the fact that it was attached to the command/service module. The command module had the only heat shield that would get us through the atmosphere of the Earth after we would jettison everything else.

We found out when we tried to maneuver using the lunar module's control systems that we had not figured nor had the lunar module been designed to be maneuvered with this mass attached to it. It's about a 60,000-pound [27,000 kilograms] dead mass that put the center of gravity way out in left field someplace. With the way the attitude jets were on the lunar module, [firing them] gave us a false movement. Put us someplace else. So, I had to learn to maneuver all over again. I had to know that when I maneuvered the handle somehow, what would happen to get me back into proper position.

***ASTRONOMY*: It was really an experimental process.**
LOVELL: Quick learning.

***ASTRONOMY*: Mission Control frantically worked on plans and communicated with you to test plans for a return. You were working on the immediate crisis, and they were contemplating and communicating with you. What was the dynamic talking to them and working through it in that first period?**
LOVELL: Well, at the beginning, it was very close. The one thing that we always had was the radio. And [Mission Control] were the ones that got us back on the free-return course while we were still married together with the two spacecraft. They were also involved with the speed-up. When we found out where we were, how much time we had to get home, we realized that we would not have enough electrical power to go around the Moon



Apollo 13 astronaut Jack Swigert sits in a rescue net as Navy personnel hoist him to a hovering helicopter. Commander Jim Lovell remains by the command module awaiting his turn. NASA

WorldMags.net

and get home safely before the power died. So they figured out how to speed up the spacecraft, first of all as we approached the Moon so that when we went around it we could light the lunar module engine and speed up to go back home again.

The one thing that I sort of complained about [was that] they had a hard time trying to figure out the final power-up of the command module — because it was dead. The guidance system had never been intended to be shut off for the entire flight. But we didn't have the [power to keep it warm]. And so they were trying to figure out the best way of powering up the command module to do the job.

They did a very good job, though, because we were being poisoned by our own exhalation. The lithium hydroxide canisters [on the lunar module] were designed to remove only carbon-dioxide exhalation from two people for two days, and we were three people for four days. It meant that we had to take a square canister, which had plenty of room in the command module, and sort of rig it into the environmental system of the lunar module that used round canisters that went into round holes. And you can't put a square canister into a round hole, obviously. So we ended up using duct tape, plastic, a piece of cardboard, and an old sock to sort of jury-rig this square canister on the outside of the lunar module system to remove the carbon dioxide. They did a very excellent job, and it kept us from being poisoned.

***ASTRONOMY*: Is it true that Jack Swigert and Fred were enamored with taking photos of the lunar farside?**

LOVELL: About the time we were approaching the Moon, they wanted to take a picture of the farside. And, of course, I was waiting to get the instructions on how to start the engine and all that. In case I missed something, I was hoping that they would pick it up. And I said, essentially, "If we don't get home, you won't get those pictures developed." And they said, "Well, you've been here before, and we haven't." So they wanted to get pictures.

***ASTRONOMY*: What was the feeling of reentry through Earth's atmosphere like?**

LOVELL: Well, as far as the spacecraft performing, it appeared just like it should because we managed to get all the power up on the command module again and with that we got the guidance system back up again. We realigned the guidance system — something which we learned on Apollo 8. [On that mission,] I inadvertently punched in the wrong program in the guidance system and had to do a manual realignment. Very, very fortunate, because in Apollo 13, we shut off the command module guidance system. And so we had to realign that guidance system with respect to the stars again so we'd have the proper attitude to come back in with respect to the atmosphere. So something like fate, that comes in handy.



The Apollo 13 crew members — (left to right) Fred Haise, Jim Lovell, and Jack Swigert — can finally breathe a sigh of relief as they step onto the deck of their recovery ship, the USS *Iwo Jima*. NASA

***ASTRONOMY*: What were the thoughts you had once you splashed down? You must have been incredibly relieved and happy.**

LOVELL: Yeah, I was incredibly relieved to think that we got back. And then I thought to myself as I was bobbing around and before I got out of the spacecraft — you know we are kind of fortunate because if that explosion had occurred just after we committed ourselves to that high velocity to go to the Moon, we would never have had enough electrical power to get all the way home again. We would have been out of electrical power. And if that explosion had occurred after we got into lunar orbit or Fred and I were on the lunar surface and came up, we'd never have enough fuel to get out of lunar orbit and to get back home again. So if we had to have an explosion on the way to the Moon, that was the time to have it.



Jim Lovell reads a newspaper account of the Apollo 13 recovery efforts on board the USS *Iwo Jima*. NASA

***ASTRONOMY*: One final question I have on a somewhat lighter note. What was the experience like of being in the film *Apollo 13* and appearing in it, as well as your association with the making of the film?**

LOVELL: With respect to the movie, I enjoyed being in it. It was a cameo spot. Actually, [the director] Ron Howard came up to me and said, "Would you want to be the admiral?" There was an admiral on board the regular ship. I said, "No, I retired as a captain — I'll dig out my old uniform, and I'll look at the ribbons that he had, and I'll put those on." So it duplicated him, and that's the way we'll go.

TO SEE AN EXTENDED VIDEO OF *ASTRONOMY*'S INTERVIEW WITH JIM LOVELL, VISIT **www.Astronomy.com/toc.**

WorldMags.net

The nature of empty

IF ASTRONOMY IS YOUR THING, it would appear that you're mostly in love with … nothing.

The universe seems to be a huge ball of emptiness. Even here on Earth, the richness around us is an illusion. Remove all the unoccupied space within each atom, and the entire human race would merely take up the volume of a sugar cube. One cubic centimeter weighing 500 million tons.

Beyond Earth, space is less empty than atoms. Fanciful sci-fi writers sometimes suggest that a solar system with its orbiting planets is analogous to electrons whirling around an atomic nucleus. It's actually a bad metaphor. Relative to the sizes of their components, atoms are 10 thousand times emptier than solar systems. Nonetheless, between planets and stars, very little is discernible to our eyes or telescopes.

Much ado about nothing

Figuring out the nature of space has obsessed humans ever since the earliest written records of Homo Bewilderus. The ancient Greeks, compulsive logicians, argued that the blank-seeming sections of the universe couldn't be empty because nothingness cannot exist. They said that for space to "be nothing" requires us to take the verb "to be" — which means to exist — and then negate it. Being nothing, they said, is a contradiction. It makes as much sense as saying, "You're running not running."

Then came the church, which chanted "amen" to the "no such thing as nothing" credo: If God is omnipresent, there cannot be any vacuum. Added to all this, many 18th- and then 19th-century scientists said that light is composed

Bob Berman *is* Astronomy*'s "Strange Universe" columnist. His newest book is* ZOOM: How Everything Moves *(Little, Brown and Company, 2014).*

THINKSTOCK: CEMIL ADAKALE/HEMERA (EARTH), EDDTORO/ISTOCK (ASTRONAUT)

WorldMags.net

space

Let's talk about nothing.

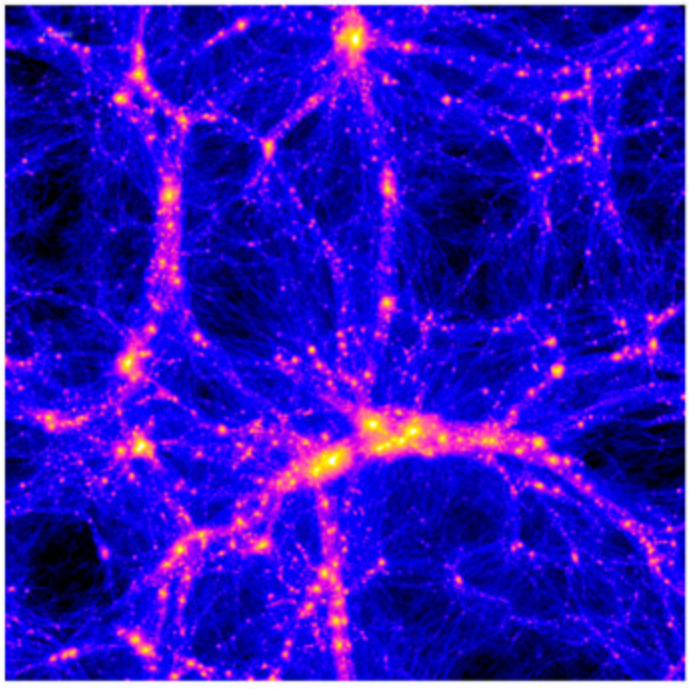
by Bob Berman



WorldMags.net



The Pipe Nebula (Barnard 59) is a dark nebula. It is conspicuous for the absence of light it causes in this region of the sky, as dense swirls of otherwise invisible dust block the light of the bright Milky Way behind it. ESO



While we can infer the presence of dark matter from watching how galaxies interact, this simulation of the dark matter distribution in the universe lets us visualize the vast networks of invisible material shaping the cosmos.
THE EAGLE COLLABORATION/J. SCHAYE/R. BOWER/J. BORROW

of waves, which require some medium through which to travel. Sound waves need air to carry the thumping bass from a teenager's car radio to a pedestrian's ear. Similarly, illumination waves from the Sun or the stars must require a medium to carry light's pulsations from there to here. The anti-nothing lobby thus included members of the scientific, religious, and philosophical communities. They ruled. If you were pro-vacuum, you were a nut job — though there were always a few dissenters, such as the noted mathematician and physicist Blaise Pascal. The universal stuff assumed to fill all space was first called a plenum, then an aether, or ether. Its existence was a given for centuries.

Evidence of absence

The ether-belief took a serious blow following one of the most famous demonstrations in history: the Michelson-Morley experiment, conducted in 1887. Albert Michelson argued that if Earth plowed through an ether, then a beam of light traveling in the same direction should get a speed boost and reflect back faster than a similar light beam aimed at right angles to it. With the help of Edward Morley, Michelson used an apparatus attached to a stable concrete platform floating atop a pool of liquid mercury. The multiple-mirror device rotated easily without introducing unwanted tilt. The results were incontrovertible: The light that traveled back and forth *across* the "ether stream" accomplished the journey in exactly the same time as light going the same distance forward in our planet's travel direction. Either Earth had stalled in its orbit around the Sun, or the ether didn't exist.

Albert Einstein settled the matter a few years later. In 1905, his first relativity theory showed that light travels happily through a vacuum. Nothing need convey its waves of electric and magnetic pulses.

This was good news. It hadn't really made sense for the planets to be passing through a substance without the slightest resistance. It was time to ax the ether with a good riddance. Now fashion totally swung the other way, and "nothing" pleased everyone. Even the church was no longer anti-vacuum.

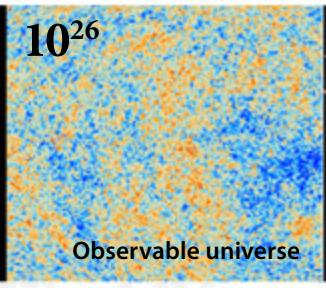
Dust in the wind

Ah, but not so fast. Light from distant stars showed the spectroscopic absorption lines of an intervening material. Some skimpy stuff — mostly hydrogen atoms, as well as atomic fragments like protons and electrons — must be occupying space after all. Simple calculations revealed that, on average, one atom floats within each cubic centimeter of space.

The degree of vacuum depends on the neighborhood. Around here, the Sun sends out a constant stream of disembodied atom fragments. This "solar wind" — the term created by physicist Gene Parker in the 1950s and confirmed during the first satellite launches — has an average density of three to six atoms per sugar cube volume. It's substantive enough to push comet tails backward like airport wind socks and make them always point away from the Sun.

Power of 10

These pictures highlight the objects that fill space, zooming in by factors of 100 or 1,000 with every step (the scale shown here is in meters). Yet at nearly every level, from the largest galaxy clusters to the smallest atoms, the distance between objects dwarfs the size of the objects themselves.



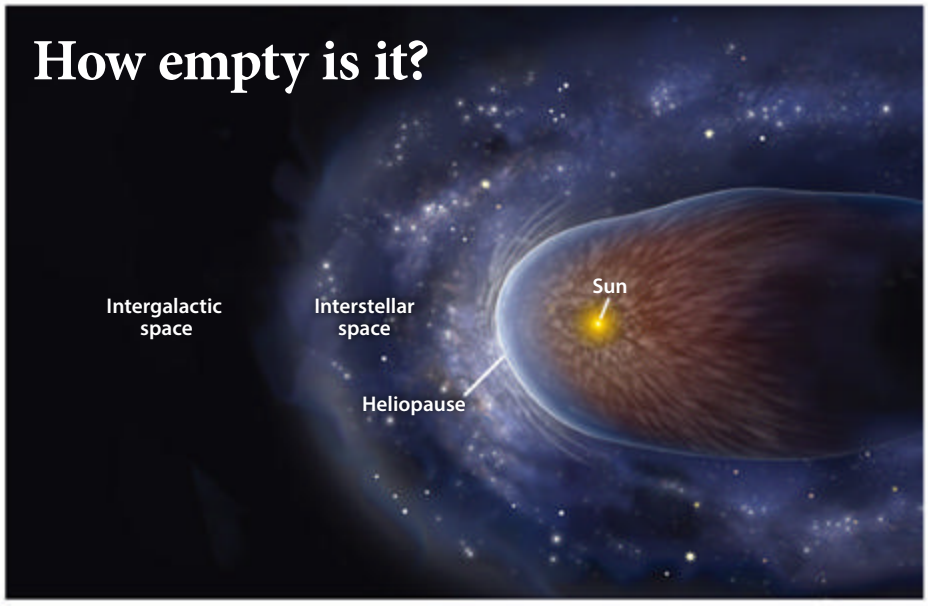




WorldMags.net



Albert Michelson's experiment with collaborator Edward Morley disproved the existence of the mysterious ether once and for all. COURTESY OF THE SMITHSONIAN LIBRARIES, WASHINGTON, D.C.



The average density of space drops dramatically from the familiar region around our Sun, to interstellar space, out to the lonely reaches of intergalactic space. *ASTRONOMY*: ROEN KELLY

In addition to those absorption lines, support for a thin interstellar medium came from the cosmic rays that continuously hit our planet. They presumably originate in distant violent events like supernovae, as stars get shredded and their detritus flung wildly outward. What's weird is that they're composed of 99 percent protons and atomic nuclei. When there are just as many electrons as protons in the universe, why are cosmic rays so proton-heavy? Write that off as an unsolved mystery, even while cosmic rays prove that particles do fill the void.

Some of these particles are barely there, streaming right through most other matter with their immeasurably tiny masses. Neutrinos fill the cosmos. So do photons of all kinds. And there's more to space than a mere recitation of its particle density. It's also permeated by "fields." Magnetic and electric fields flow across the whole of space. Gravity waves rock its very fabric. Thus, a lot is present even if it all weighs little or nothing.

The power of nothing

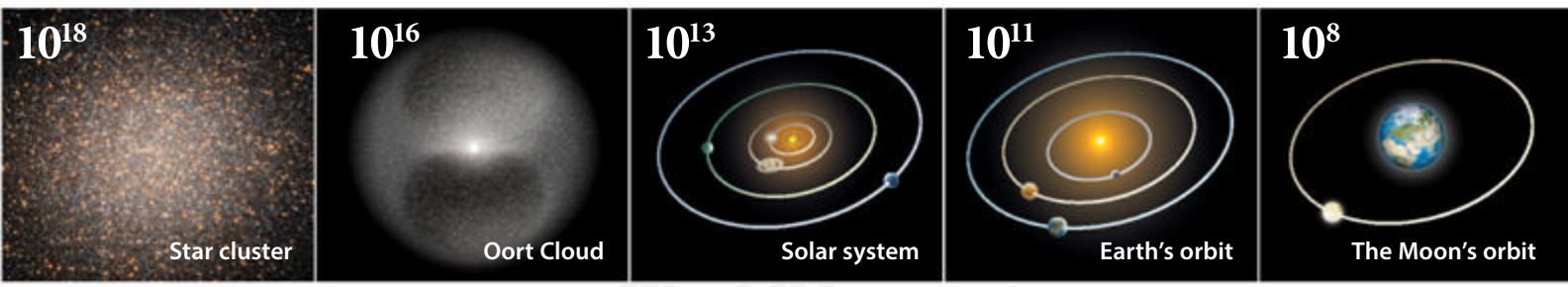
Most intriguing, perhaps, is space's omnipresent "vacuum energy" first postulated in the 1930s. Also called zero-point energy, it's the underlying matrix of the cosmos. While mysterious, there are good reasons to believe it exists. For example, in 1948, the Dutch physicist Hendrik Casimir showed that closely spaced metal plates become powerfully pressed together, presumably by the waves of vacuum energy outside them. (The tiny space between the plates stifles the energy waves by leaving them insufficient "breathing room" to push back against the force.)

Most physicists accept that vacuum energy causes the Casimir effect. Calculations of how much vacuum energy lurks everywhere vary greatly (in fact, the 100 orders of magnitude difference between theoretical predictions and measured values is known as the vacuum catastrophe), but it's substantial. By the larger estimate, if this energy could be extracted and utilized, each empty mayonnaise jar of space contains enough power to boil off the Pacific Ocean in one second. This underlying energy seems to be caused by an endless whirl of particles and antiparticles springing briefly into existence in every tiny piece of space and then vanishing again. It's as if the entire cosmos, despite the appearance of emptiness, seethes with so much energy that it can barely contain itself.

This may be the so-called "dark energy" making the cosmos expand. If this quality of space is the underlying cause of the Big Bang, then the universe is still banging. All thanks to "empty" space.

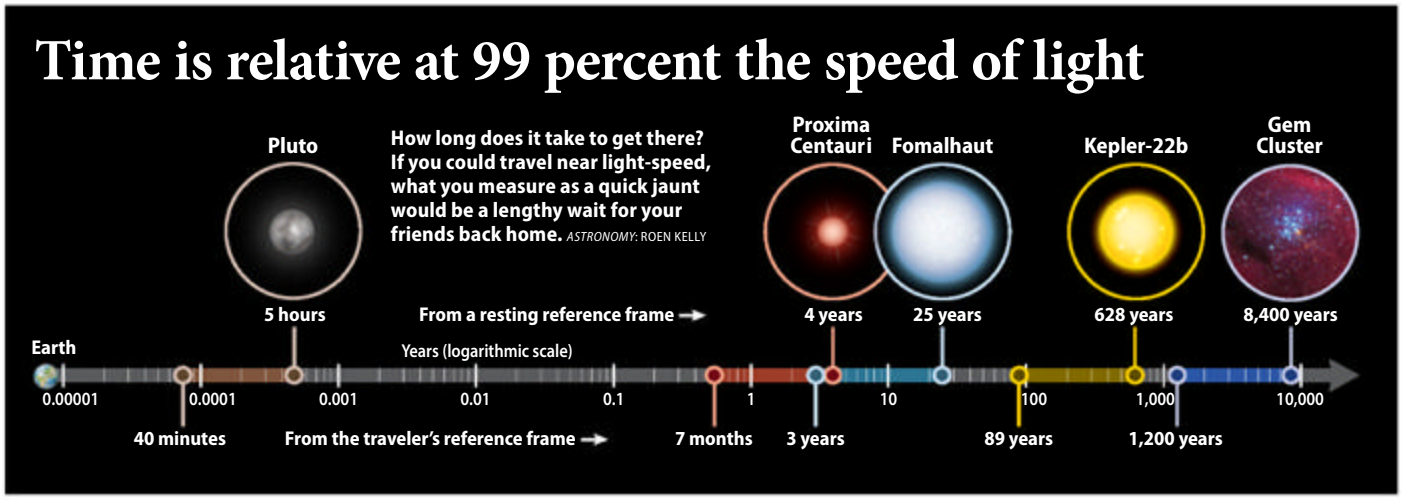
A matter of perspective

Weird, but we could live with it. Harder to grasp is an entirely different aspect of emptiness — one that has changed space from logical to enigmatic. Since the late 1990s, experiments have confirmed the reality of an aspect of quantum theory known as entanglement. Here, two bits of light or actual physical objects, even clumps of material that were created together, fly off and live separate lives, but are always "aware" of the other's status. If one is measured or observed, its twin knows this is happening and instantaneously assumes the guise of a particle or bit of light with complementary properties. No matter how far these twins are separated, they behave



WorldMags.net

ESA/PLANCK COLLABORATION (10^{28}); NASA/ESA/M. MONTES (IAC)/J. LOTZ, M. MOUNTAIN, A. KOEKEMOER, HFF TEAM (STScI) (10^{23}); NASA/ESA/HUBBLE HERITAGE TEAM (STScI/AURA) (10^{21}, 10^{18}); *ASTRONOMY*: ROEN KELLY (10^{16}, 10^{13}, 10^{11}, 10^{8})



ENTANGLEMENT STANDS

Albert Einstein had strong feelings against quantum entanglement (and indeed, quantum mechanics as a whole), which he called "spooky actions at a distance." He firmly rejected the idea that physics might not be "local" (objects must be in physical proximity in order to affect each other) or "real" (meaning here that objects have a predetermined state prior to being measured). If locality did not exist, then Einstein's own laws of relativity were flawed because they were incompatible with information being transmitted instantaneously across space. If reality did not exist, then … frankly this idea was simply deeply disturbing. It was easier to believe in "hidden variables," or the idea that, contrary to quantum laws, particles have a "true" state that is revealed, rather than determined, by observation.

In 1935, Einstein, along with Boris Podolsky and Nathan Rosen, proposed the EPR Paradox. They claimed that the absurdity of entanglement — twinned particles randomly choosing complementary states and then communicating that information across immeasurable space — must prove quantum theory flawed, or at best incomplete. In 1964, John Bell continued their thought experiment, developing testable hypotheses (Bell's inequalities) that would prove we live in a classically determined universe. So far, experiments have consistently *disproven* Bell's inequalities, negating Einstein's paradox and showing that the universe we live in does *not* require local realism. Weird as it sounds on a human scale, the universe is measurably unreal on a fundamental level.

And yet there is one loophole left to close in Bell's theorem, probably the weirdest yet: free will. Bell's theorem suggests that quantum mechanics could be disproven if humans lack free will. If we are preprogrammed in the observations we make, then entangled particles aren't required to perform any "spooky actions." The universe knows what we will measure before we start. Not all scientists put stock in this interpretation, but others are hard at work finding ways to test this last holdout for a classical world. Spooky. — *Korey Haynes*

as if they are still two sides of one coin, aware of and in tune with their other half's identity without any lag across space and time.

This strongly suggests that the gap between bodies is not real on some level. Emptiness is not what we assumed it to be. If even distant objects are in contact, what does this say about space or separation?

And wait, it gets worse. Einstein's relativity shows that space is not a constant and therefore not inherently substantive. High-speed travel makes intervening space dramatically shrink. Thus when we step out under the stars, we may marvel at their distances and the universe's vast spaces. But it has been shown repeatedly that this seeming separation between ourselves and anything else is subject to point of view — what Einstein called a "reference frame" — and therefore has no *inherent* bedrock reality. This doesn't by itself negate space but merely makes it tentative.

If we lived on a world with a very strong gravitational field or traveled outbound at a high speed, those stars would lie at entirely different distances. If we headed toward the star Procyon at 99 percent of light-speed, we would find that it was actually less than 2 light-years away, not the 11 light-years we'd previously measured it to be. If we crossed a living room 21 feet (6 meters) in length going at that speed, every instrument in our perception would show that it's actually now 3 feet (1m) long. And if we could move at 99.9999999 percent of light-speed, which is perfectly allowable by the laws of physics, the living room would now be barely larger than the period at the end of this sentence. Space would have changed to nearly nothing. Where, then, is the supposedly trustworthy space matrix, the gridwork within which we observe the stars and galaxies?

In the mind's eye?

More abstractly, we could even wonder whether space has an objective reality or is merely our minds' efforts to give order to what we see. Is space part of the mental logic of the animal organism, the software that molds sensations into multidimensional objects?



WorldMags.net

Universal roll call



It can be more than a little disconcerting to think that everything in existence we can see, touch, or affect makes up only a small fraction of the universe as a whole. *ASTRONOMY*: ROEN KELLY



Edwin Hubble observed a multitude of galaxies, including the Pinwheel (M101), in order to make the startling and disturbing discovery that space itself is expanding. NASA/ESA/K. KUNTZ (JHU)/F. BRESOLIN (UNIVERSITY OF HAWAII)/J. TRAUGER (JET PROPULSION LAB)/J. MOULD (NOAO)/Y.-H. CHU (UNIVERSITY OF ILLINOIS, URBANA)/STScI

Most of us regard space as if it were a vast container without walls. Inside this huge floorless cathedral lurks the appearance of myriad separate objects. Seeing them as individual items requires that each object be isolated and identified as a pattern imprinted on the mind. We then also require surrounding space if we are to identify them as separate entities.

But what if visible objects are merely bits of flotsam materializing out of the vastly more powerful underlying vacuum energy, which is ignored because it's visually imperceptible? In a different mindset, might we perceive a fundamental oneness rather than distinct entities separated by space? If known objects are blocked out within boundaries of color, shape, or utility only by the thinking mind, then we might ask if space is always a reality rather than mere perception.

Then, too, a minority school is convinced that the observer and the universe are correlative. By this reasoning, the space "out there" is part of a continuum of consciousness and nothing exists apart from the observer. If so, the farthest regions of space are located here in our minds. Well, OK, maybe forget that one for now, since it would require a hundred pages of persuasive explication to seem anything other than lunatic.

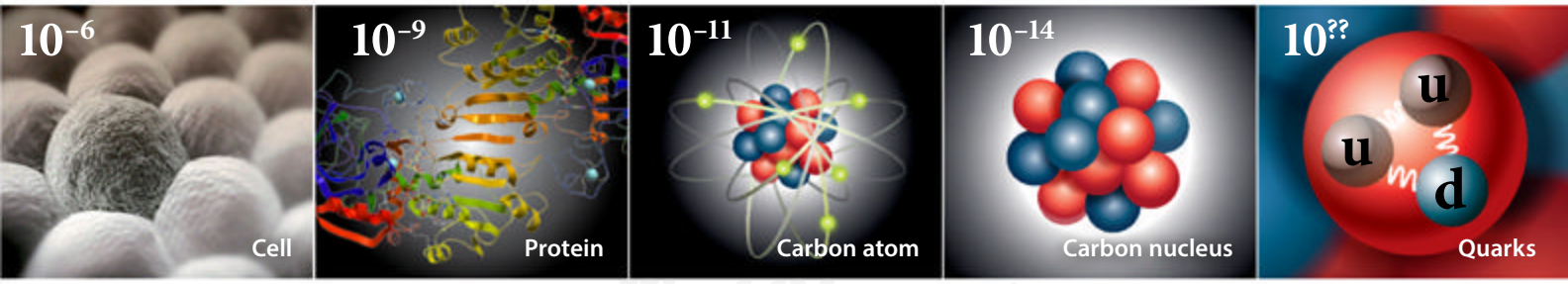
In sum, there are multiple reasons why space cannot be the simple blank gap between bodies assumed not too long ago. Shall we count the ways? (1) Empty space is never empty, especially when we include fields, photons, neutrinos, vacuum energy, and transient particle pairs. (2) Distances between objects mutate depending on a multitude of relativistic conditions so that no inviolable distance exists anywhere, between anything and anything else. (3) Quantum theory casts serious doubt about whether even far-apart bodies are truly and fully separated. (4) Separations between objects are often called space only because language and convention makes us draw boundaries. Is it "outer space" inside the Sun, in the vast empty gaps between and within its atoms?

The mental torment imposed by the issue of space shows no sign of abating. Theoretical physicists wonder if there is a smallest possible amount of space that cannot be subdivided; some say yes. Others propose additional dimensions to space beyond the three spatial dimensions and a fourth constituting time. There are complex, mathematically plausible arguments for extra, unseen dimensions. On the other hand, many scientists say that additional space dimensions are mere speculation and must remain so unless some actual experimental or observational evidence comes to light.

Even crossing off the wacky-sounding stuff, we're left with a lot to think about. We started with a simple question: What is space, the main component of the cosmos?

And we end up with our heads spinning.

FOR MORE NOT-SO-SPOOKY ACTIONS IN QUANTUM ENTANGLEMENT, CHECK OUT **www.Astronomy.com/toc.**



WorldMags.net

NOAA/NASA GOES PROJECT (10^{9}); THINKSTOCK; RON CHAPPLE STOCK/RON CHAPPLE STUDIOS (10^{3}); PIXLAND (10^{0}); THINKSTOCK/ISTOCK; DENYS PRYKHODOV (10^{-3}); JEKA 1984 (10^{-6}), UGREEN (10^{-9}), RAILELECTROPOWER A (10^{-9}); *ASTRONOMY*: ROEN KELLY (10^{-11}, 10^{-14}, $10^{??}$)

MARTIN RATCLIFFE and **ALISTER LING** describe the solar system's changing landscape as it appears in Earth's sky.

Visible to the naked eye
Visible with binoculars
Visible with a telescope

June 2015: Venus meets Jupiter at dusk



Brilliant Venus passed a few degrees to Jupiter's upper right in evening twilight March 14, 2012. The two worlds will appear even closer during a return engagement in late June. JAMIE COOPER

Although June nights are the shortest of the year in the Northern Hemisphere, in 2015 they pack a powerful punch. Venus and Jupiter will top most observers' lists by dominating the evening sky all month. Keep a watch on the two brightest planets as the weeks pass, and you'll notice them pulling closer. The drama builds to a stunning climax when they pass within 0.3° of each other as the calendar turns from June to July.

But the thrills don't stop there. June also features Saturn just a few weeks past its peak, Uranus and Neptune coming into sharper focus after midnight, and Mercury making a brief appearance before dawn.

June's first evening reveals two brilliant planets lighting up the western sky. **Venus** and **Jupiter** stand 20° apart that night. Although Venus appears lower, it shines 10 times brighter than its companion (magnitude –4.4 compared with magnitude –1.9). You'll spot Venus easily within 30 minutes of sunset, when it appears 30° above the horizon. A half-hour later, the planet is a stunning jewel set against the darkening sky.

Venus lies among the background stars of eastern Gemini on the 1st, forming a straight line with the Twin's brightest stars, Castor and Pollux. The inner world crosses into Cancer the Crab on June 3. It reaches greatest elongation three days later, when it lies 45° east of the Sun and sets after 11:30 P.M. local daylight time. Venus slides less than 1° north of the Beehive star cluster (M44) June 12 and 13, making a splendid sight through binoculars. The best views will come about an hour after sunset, before the planet dips too low.

As Venus pulls within 7° of Jupiter on June 19, a crescent Moon joins the scene some 7° below Venus. Compare our satellite's 13-percent-lit disk to a telescopic view of Venus' fatter crescent, which is 42 percent lit. The next evening, the waxing Moon lies 5° to Jupiter's lower left.

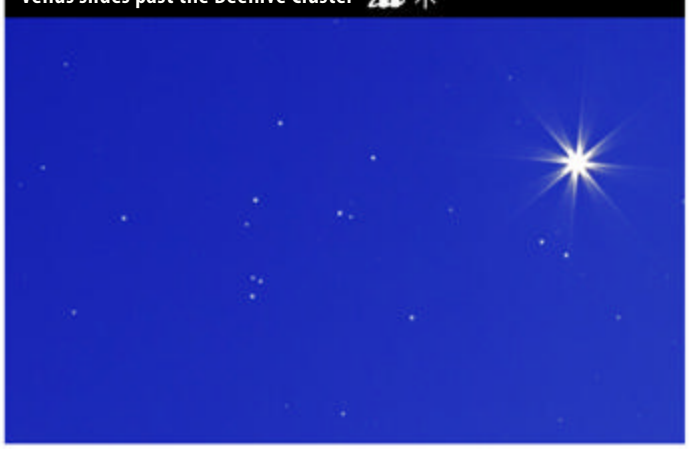
Venus crosses into Leo the Lion on June 25. The separation between it and Jupiter has now shrunk to 3°, and the brilliant planets look like a pair of cat's eyes catching a car's headlights in the dark. The gap keeps closing over the next five nights, reaching a minimum of just 20' (two-thirds of the Full Moon's diameter) on the 30th. Both planets will appear in a single field of view through a telescope at low power.

Although conjunctions between Venus and Jupiter typically occur every year or two, this event is the first and closest in a rare triple conjunction. The second occurs July 31 in the evening sky and the third October 26 before dawn. An even closer conjunction (4' separation) comes August 27, 2016, but the pair then will be in bright twilight.

If you want to view Venus through a telescope, do so before darkness fully settles in. Twilight reduces the stark contrast between the planet and sky and makes detail stand out. On June 1, Venus appears 22" across and just over half-lit. It reaches 50 percent illumination at greatest elongation on the 6th, when it resembles a miniature First Quarter Moon. By month's end, the planet's disk spans 32" and is about one-third lit.

As with Venus, Jupiter benefits from early evening observing. The giant planet

Venus slides past the Beehive Cluster



The stars of the Beehive Cluster (M44) made a stunning backdrop for Venus on July 3, 2013. The planet revisits the cluster June 12 and 13. LUIS ARGERICH

Martin Ratcliffe *provides planetarium development for Sky-Skan, Inc., from his home in Wichita, Kansas. Meteorologist* **Alister Ling** *works for Environment Canada in Edmonton, Alberta.*

WorldMags.net

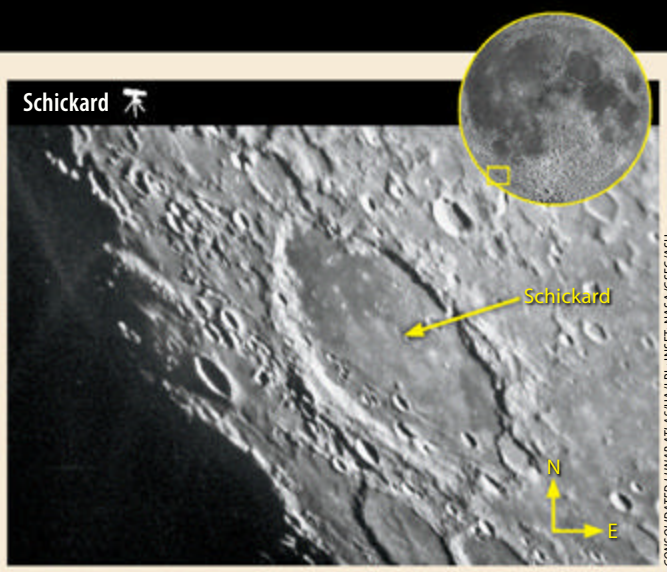
RISING**MOON**

Punched, flooded, sprayed, and strafed

One lunar feature nicely encapsulates much of the Moon's history. The crater Schickard stands out near the southwestern limb in the days around Full Moon (June 2 this month). Your eyes will thank you if you reduce the lunar disk's excessive glare. Using a smaller telescope than usual, pumping up the magnification, or screwing in a dark filter will help.

To get the full effect of viewing Schickard, start observing a couple of evenings early. On May 30, the first rays of sunlight strike the flooded crater at a glancing angle, highlighting differences in the heights of smaller features. You'll quickly discern that this is an old crater because its rim appears battered; in contrast, the smaller craters pocking the smooth floor display the classic sharp edges of relative youth. Schickard's western wall, which would have been steep at the moment of formation, abruptly slumped down into terraces that remain visible today. The higher Sun on the following two evenings seemingly erases these features.

Schickard transforms into a two-faced depression on the following nights, with an unusual stripe of lighter gray material painted across the middle of the floor. A large impact carved out this 132-mile-wide crater some 4 billion years ago. Lava soon welled up and covered its central peaks. Then the giant Mare Orientale impact to the west sprayed the whole region with lighter-colored material. A final surge of lava covered the northern and southern portions of the bowl but did not rise high enough to erase the lighter stripe.



CONSOLIDATED LUNAR ATLAS/UA/LPL; INSET: NASA/GSFC/ASU

Catch lunar history on display when the Sun illuminates 132-mile-wide Schickard Crater in the days around Full Moon.

When the Sun returns to the crater June 28, it displays dramatic shadows that camouflage the different shades. Within a couple of days, however, the stripe returns to prominence.

then lies higher in the sky, so its light passes through less of Earth's image-distorting atmosphere. For the same reason, early June offers superior views because Jupiter lies more than a third of the way to the zenith an hour after sunset.

Once you've sampled the delicate details in Jupiter's cloud tops — the alternating series of bright zones and darker belts, turbulent eddies, and giant storms — turn your attention to the planet's four bright moons. These so-called Galilean satellites orbit Jupiter with periods ranging from 1.8 to 16.7 days. Because both Earth and the Sun now lie in the plane of the orbits, one moon may cross in front of another (an occultation) or pass through another's shadow (an eclipse). Unfortunately, the current series of mutual events is winding

— *Continued on page 42*

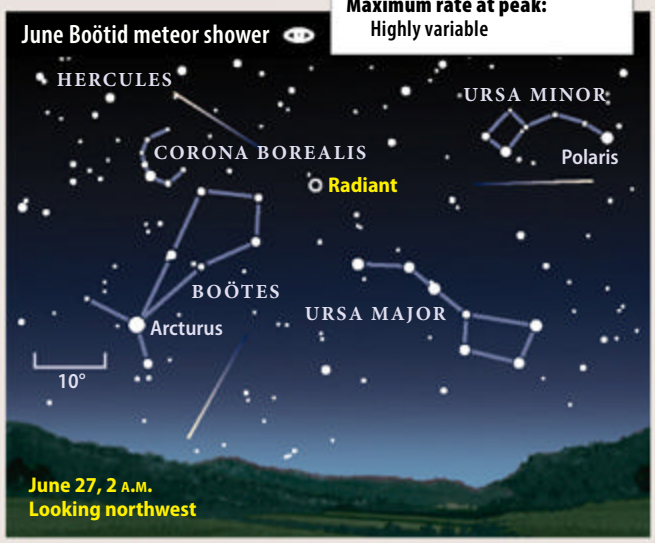
METEORWATCH

The Herdsman's laid-back shooting stars

June Boötid meteors
Active Dates: June 22–July 2
Peak: June 27
Moon at peak: Waxing gibbous
Maximum rate at peak: Highly variable

Northern Hemisphere meteor observers face two obstacles during June. First, the month delivers the shortest nights of the year, with areas north of 50° north latitude never achieving complete darkness. Second, June offers no major meteor showers.

This month's best minor shower is the June Boötids, which peaks June 27. Astronomers don't expect much activity this year, but you won't know if you don't look. The waxing gibbous Moon sets around 2 A.M. local daylight time on the 27th, leaving an hour or two of darkness for those at mid-northern latitudes. June Boötid meteors hit Earth at "only" 11 miles per second, the slowest of any shower.



Observers should be on the lookout for the slow-moving meteors of the June Boötid shower, which peaks June 27. ALL ILLUSTRATIONS: *ASTRONOMY*: ROEN KELLY

OBSERVING HIGHLIGHT Venus reaches its peak June 6, when it lies 45° from the Sun and appears some 25° above the western horizon an hour after sunset.

WorldMags.net

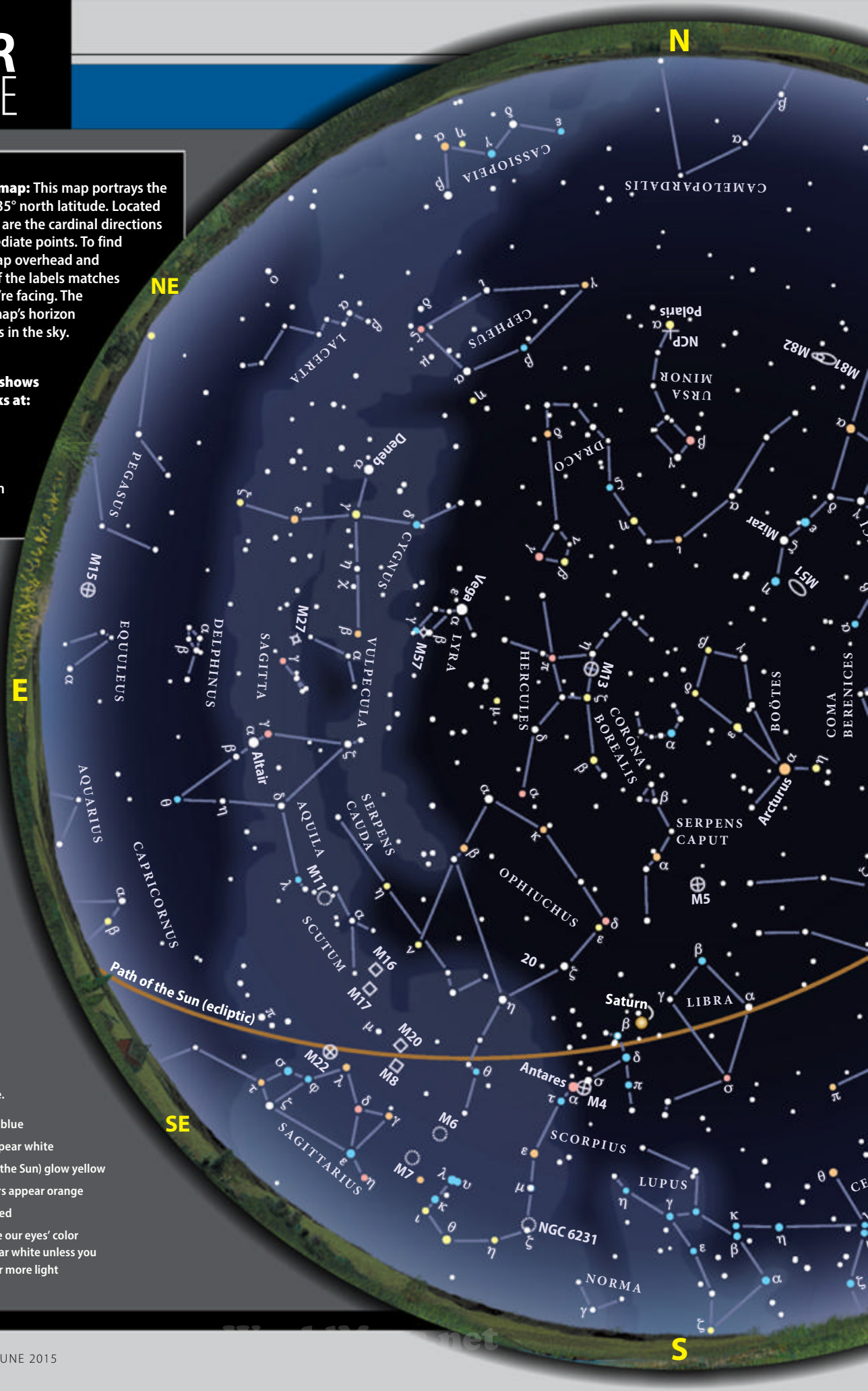
STAR DOME

How to use this map: This map portrays the sky as seen near 35° north latitude. Located inside the border are the cardinal directions and their intermediate points. To find stars, hold the map overhead and orient it so one of the labels matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

The all-sky map shows how the sky looks at:

midnight June 1
11 P.M. June 15
10 P.M. June 30

Planets are shown at midmonth



STAR MAGNITUDES

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0

STAR COLORS

A star's color depends on its surface temperature.

- The hottest stars shine blue
- Slightly cooler stars appear white
- Intermediate stars (like the Sun) glow yellow
- Lower-temperature stars appear orange
- The coolest stars glow red
- Fainter stars can't excite our eyes' color receptors, so they appear white unless you use optical aid to gather more light



See tonight's sky in Astronomy.com's STARDOME

JUNE 2015

Note: Moon phases in the calendar vary in size due to the distance from Earth and are shown at 0h Universal Time.

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

Calendar of events

1 The Moon passes 1.9° north of Saturn, 4 P.M. EDT

2 Full Moon occurs at 12:19 P.M. EDT

6 Venus is at greatest eastern elongation (45°), 2 P.M. EDT

Asteroid Ceres is stationary, 6 P.M. EDT

8 The Moon passes 3° north of Neptune, 11 P.M. EDT

9 Last Quarter Moon occurs at 11:42 A.M. EDT

10 The Moon is at perigee (229,728 miles from Earth), 12:44 A.M. EDT

11 Mercury is stationary, 4 P.M. EDT

The Moon passes 0.5° south of Uranus, 4 P.M. EDT

Asteroid Pallas is at opposition, 9 P.M. EDT

12 Neptune is stationary, 4 P.M. EDT

14 Mars is in conjunction with the Sun, noon EDT

The Moon passes 0.04° south of Mercury, 10 P.M. EDT

15 The Moon passes 1.0° north of Aldebaran, 8 A.M. EDT

16 New Moon occurs at 10:05 A.M. EDT

20 The Moon passes 6° south of Venus, 7 A.M. EDT

The Moon passes 5° south of Jupiter, 8 P.M. EDT

21 Summer solstice occurs at 12:38 P.M. EDT

23 The Moon is at apogee (251,116 miles from Earth), 1:00 P.M. EDT

24 Mercury passes 2° north of Aldebaran, 4 A.M. EDT

First Quarter Moon occurs at 7:03 A.M. EDT

Mercury is at greatest western elongation (22°), 1 P.M. EDT

28 The Moon passes 2° north of Saturn, 9 P.M. EDT

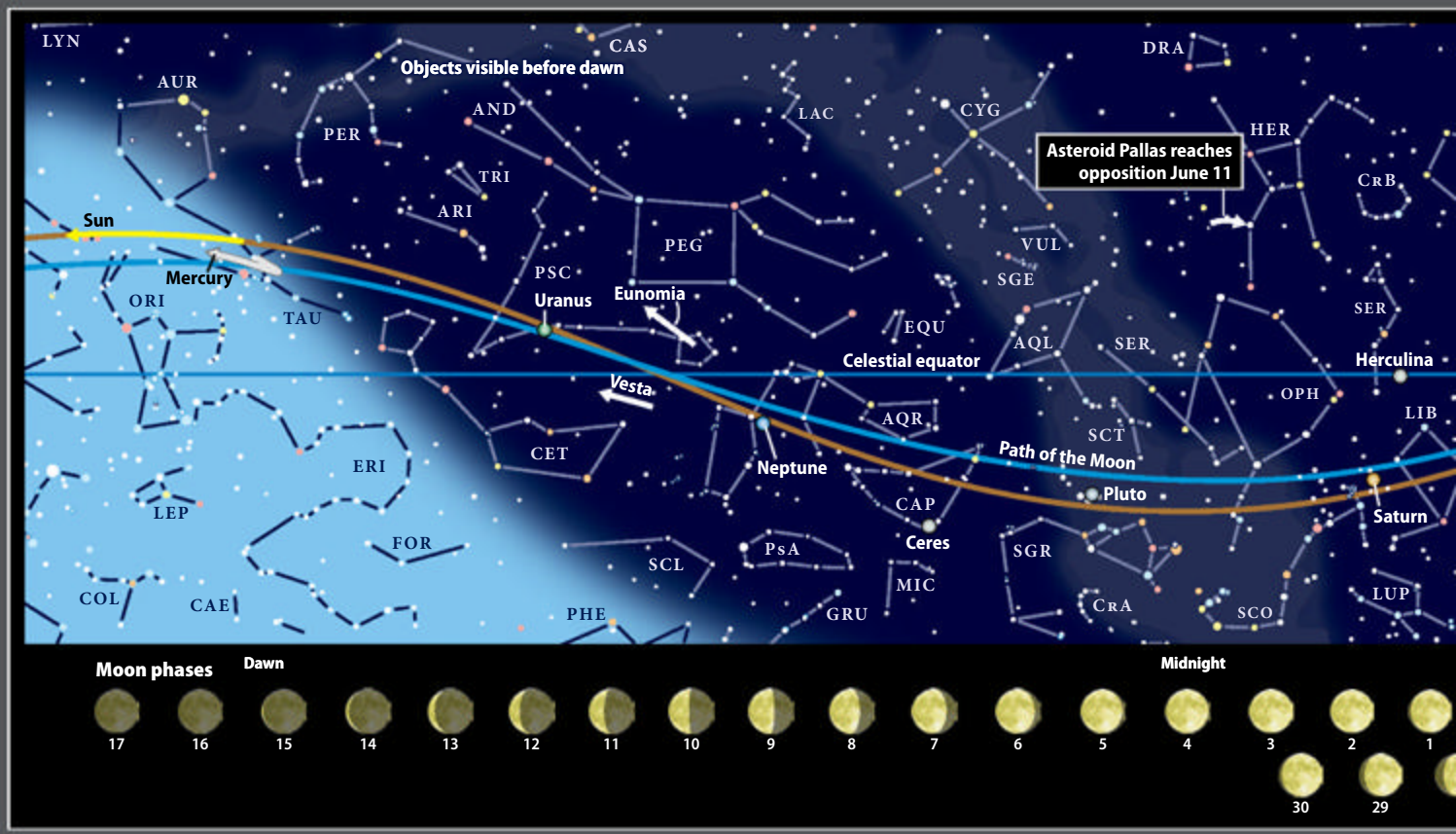
SPECIAL OBSERVING DATE

30 Venus and Jupiter come within 0.3° of each other in the evening sky.

BEGINNERS: WATCH A VIDEO ABOUT HOW TO READ A STAR CHART AT **www.Astronomy.com/starchart.**

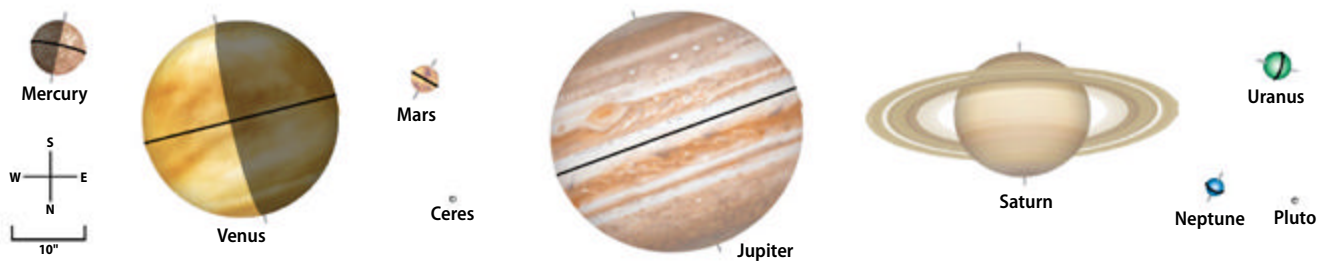
PATH OF THE PLANETS

The planets in June 2015

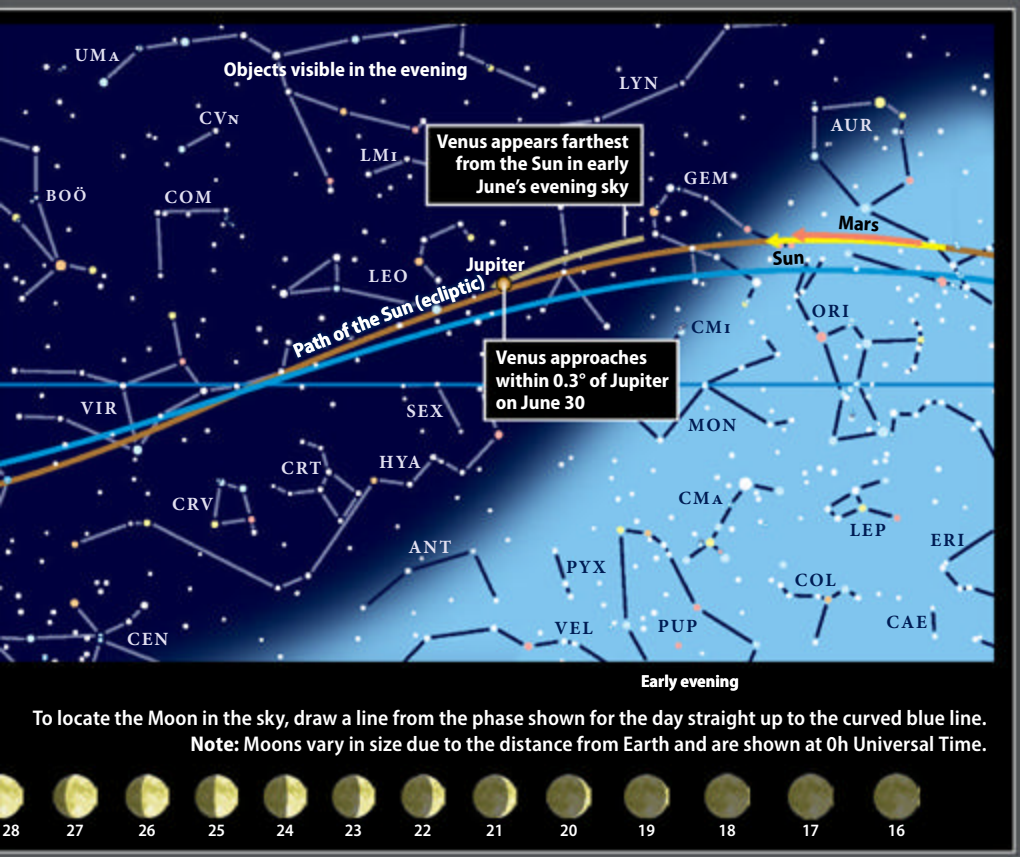


The planets in the sky

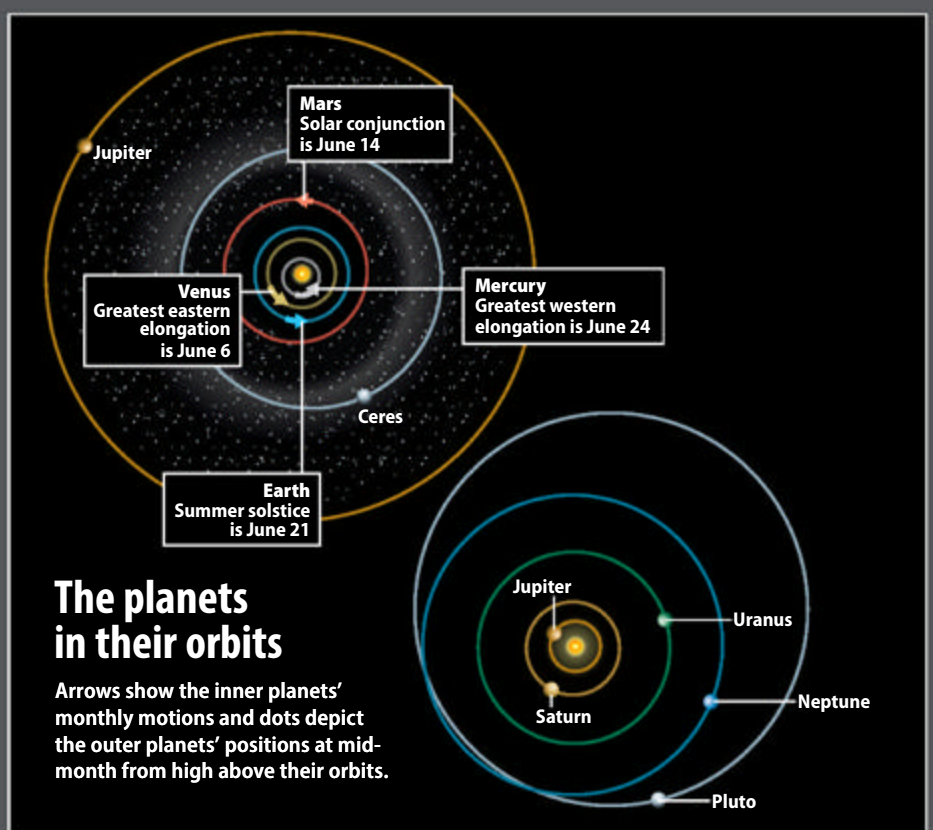
These illustrations show the size, phase, and orientation of each planet and the two brightest dwarf planets for the dates in the data table at bottom. South is at the top to match the view through a telescope.



Planets	MERCURY	VENUS	MARS	CERES	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Date	June 30	June 15	June 15	June 15	June 15	June 15	June 15	June 15	June 15
Magnitude	–0.1	–4.5	1.5	8.2	–1.9	0.1	5.9	7.9	14.1
Angular size	7.1"	26.0"	3.6"	0.6"	33.5"	18.4"	3.5"	2.3"	0.1"
Illumination	49%	45%	100%	98%	99%	100%	100%	100%	100%
Distance (AU) from Earth	0.942	0.643	2.569	2.126	5.885	9.044	20.421	29.706	31.942
Distance (AU) from Sun	0.374	0.724	1.553	2.926	5.369	9.982	19.993	29.965	32.890
Right ascension (2000.0)	5h01.5m	8h45.9m	5h30.7m	20h53.5m	9h25.0m	15h52.3m	1h13.4m	22h45.8m	19h02.3m
Declination (2000.0)	20°16'	20°06'	23°53'	–26°02'	16°06'	–18°00'	7°05'	–8°42'	–20°38'



To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.
Note: Moons vary in size due to the distance from Earth and are shown at 0h Universal Time.

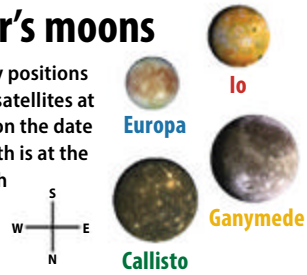


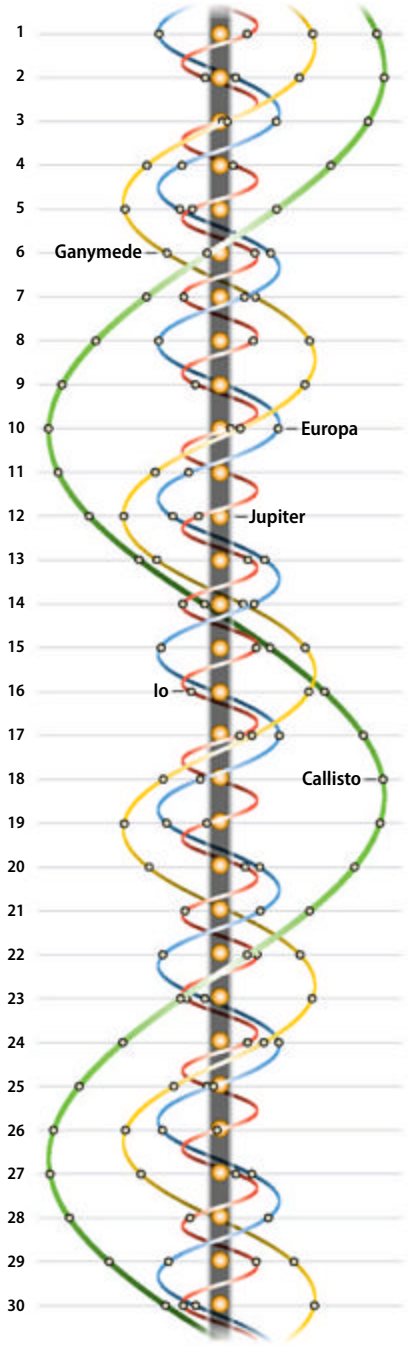
The planets in their orbits

Arrows show the inner planets' monthly motions and dots depict the outer planets' positions at mid-month from high above their orbits.

Jupiter's moons

Dots display positions of Galilean satellites at 11 P.M. EDT on the date shown. South is at the top to match the view through a telescope.





ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

— Continued from page 37

WHEN TO VIEW THE PLANETS

EVENING SKY	MIDNIGHT	MORNING SKY
Venus (west)	Saturn (south)	Mercury (northeast)
Jupiter (west)		Uranus (east)
Saturn (southeast)		Neptune (southeast)

down, and with Jupiter visible for only a few hours each night, North American observers can see only a half dozen or so during June.

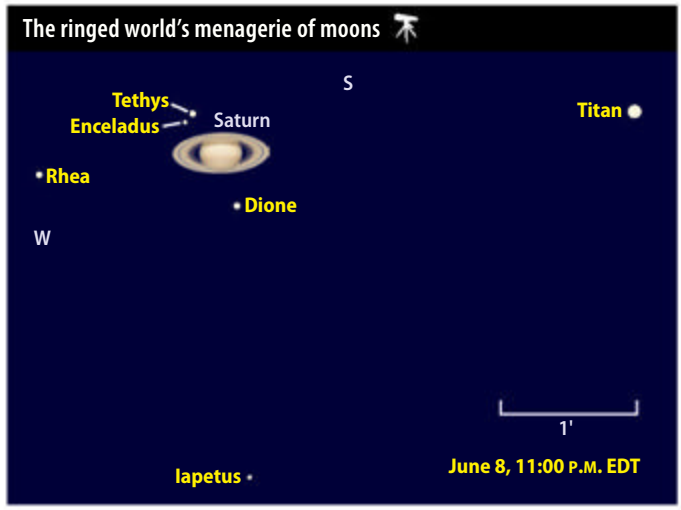
A nice event visible from the continent's eastern half occurs as darkness falls June 3. Ganymede eclipses Io for 28 minutes starting at 9:43 P.M. EDT. Io shines only three-quarters of its normal brightness at mideclipse. Ganymede — the solar system's largest moon — adds extra spice by appearing in transit across the planet's disk during the event. Io begins to transit Jupiter at 10:47 P.M. EDT followed by its shadow at 11:56 P.M. Just one minute after that, Ganymede clears the gas giant's disk. The big moon's shadow, which got this whole affair started, touches the jovian cloud tops beginning at 12:58 A.M. EDT, after Jupiter has set for East Coast observers.

Perhaps the best event for those living in western North America occurs the evening of June 10. Ganymede occults Io from 9:55 to 10:18 P.M. PDT while both moons are transiting Jupiter.

As Jupiter descends in the western sky, **Saturn** climbs in the east. Although it reached opposition and peak visibility in late May, the ringed planet's appearance hardly suffers in June. It dims almost imperceptibly this month, from magnitude 0.1 to 0.2, and its size when viewed through a telescope shrinks only 2 percent. Saturn's higher altitude and better visibility during the evening hours easily make up for these minor losses.

The solar system's second-largest planet is set against the faint backdrop of eastern Libra, though it's not far from the riches of Scorpius. It lies a bit more than 10° northwest of 1st-magnitude Antares, the Scorpion's brightest star. The Moon appears Full when it passes near Saturn the evening of June 1 and shows a bright gibbous phase when it returns on the 28th.

A telescope turns Saturn from a steadily shining point of light into a wondrous ringed world. In mid-June, the planet's globe measures



All of Saturn's bright moons appear near the planet the evening of June 8, including distant Iapetus, which then lies due north of the gas giant.

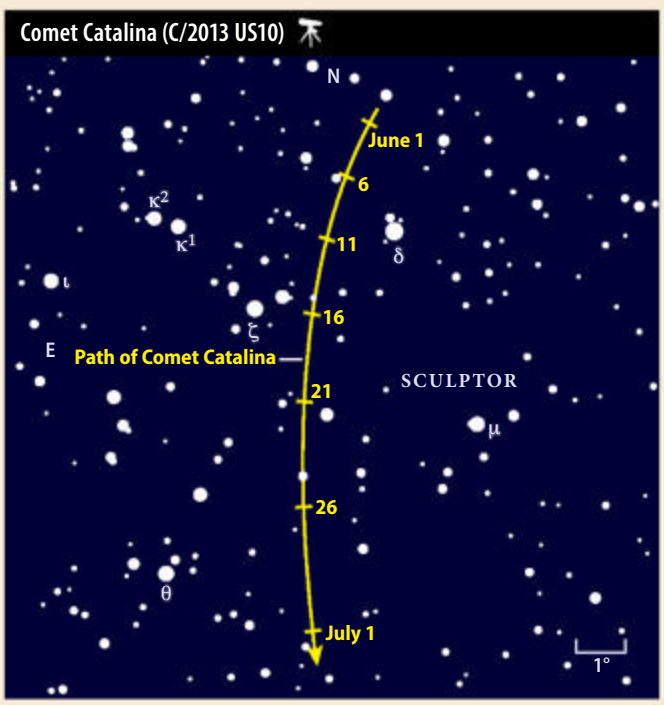
COMETSEARCH

Catalina scrapes the predawn horizon

Will the comet gods deliver on their next promise? Astronomers predict that Comet Catalina (C/2013 US10) will be visible to the naked eye late this year. Observers have a chance to catch a preliminary view of this visitor from the Oort Cloud during June as it dives south through Sculptor.

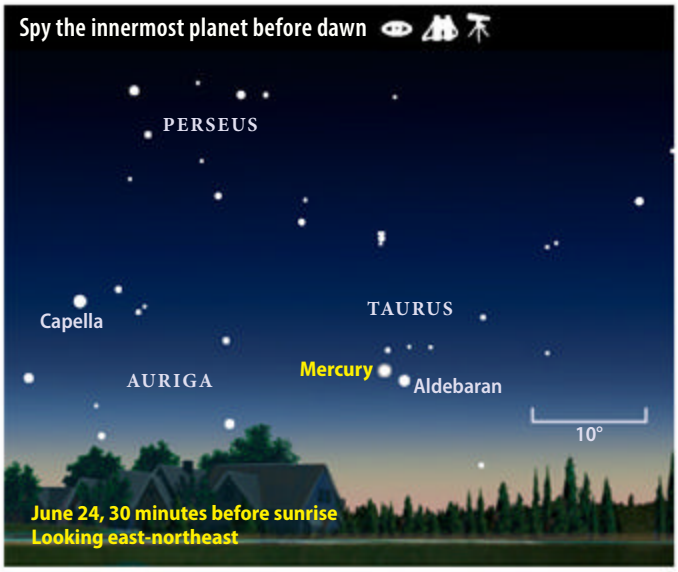
This constellation hangs low in the southeastern sky shortly before morning twilight begins. (Observers in the Southern Hemisphere can find Sculptor just below 1st-magnitude Fomalhaut as it climbs in the eastern sky after midnight.) Comet experts expect Catalina to be glowing around 8th or 9th magnitude in June. The comet should look nearly round at this stage, though its northeastern flank will look slightly more defined where solar radiation pushes against the comet's dusty envelope.

Northern Hemisphere viewers will have to wait for Catalina to make a long sojourn through the southern sky before it returns to view in late November. By then, the comet could be glowing at 4th or 5th magnitude as it shares the morning sky with Venus. It then will cruise past magnitude 0.0 Arcturus as the calendar ticks over to 2016. Astronomers with the U.S.-based Catalina Sky Survey discovered the comet October 31, 2013. The designation "US" in its official name comes from the chronological order of its discovery, however, and not the country of those who found it.



A possible naked-eye object late this year, Comet Catalina should glow at 8th or 9th magnitude in June as it chisels its way south through Sculptor.

WorldMags.net



Mercury hangs low on mornings around June 24, when it lies 22° west of the Sun at its summertime peak for Northern Hemisphere observers.

18" across its equator while the rings span 42" and tilt 24° to our line of sight. The best views come within an hour or so of when Saturn climbs highest in the south, at roughly midnight local daylight time June 1 and two hours earlier by the 30th.

After savoring the photons reflecting off Saturn and its rings, turn your attention to the planet's array of bright moons. Giant Titan glows at 8th magnitude and shows up through any telescope. It's the brightest point of light in Saturn's vicinity except on June 23 and 24, when the planet and its attendants slide within 2' of a 7th-magnitude background star.

Titan revolves around Saturn once every 16 days. Three 10th-magnitude moons — Tethys, Dione, and Rhea — circle the planet inside of Titan's orbit. They appear clearly through 4-inch and larger scopes. An 8-inch instrument will bring in 12th-magnitude Enceladus when this inner moon lies farthest from Saturn.

Outer Iapetus is the Dr. Jekyll and Mr. Hyde of solar system objects. One of its hemispheres reflects light like newly fallen snow, while the opposite side more closely resembles coal. The moon's brightness varies from 10th magnitude when it lies farthest west of Saturn and its reflective side faces us to 12th magnitude when it stands farthest east. The easiest times to spot it this month come on the evenings of June 7–9 when it passes north of Saturn and glows at 11th magnitude. Iapetus fades thereafter as it heads toward greatest eastern elongation June 28.

Neptune is a binocular object before dawn, when it lies in the southeastern sky among the background stars of Aquarius. It remains 2° southwest of 4th-magnitude Lambda (λ) Aquarii all month. The planet glows at magnitude 7.9, so it is a dim object in 7x50 binoculars, and the handful of similarly bright stars in its neighborhood makes identification difficult. To confirm a sighting, point your telescope at the suspected planet. Only Neptune will show a blue-gray disk measuring 2.3" across.

Like its outer neighbor, **Uranus** shows up best shortly before dawn starts to paint the sky. The magnitude 5.9 planet lies against the faint stellar backdrop of Pisces. Use magnitude 5.2 Zeta (ζ) Piscium as a guide. Uranus lies within 1° of this star all month and passes 0.5° due south of it June 18. A telescope reveals Uranus' 3.5"-diameter disk and blue-green color.

Our final solar system target appears low in the east-northeast before dawn in late June. **Mercury** reaches greatest elongation on the 24th, when it lies 22° west of the Sun and stands 7° high a half-hour before sunrise. Shining at magnitude 0.4, it shows up easily through binoculars if you have an unobstructed horizon. Don't confuse it with ruddy Aldebaran, the 1st-magnitude luminary of Taurus, which lies 2° south (lower right) of the planet that morning. A telescope will show Mercury's disk, which appears 8" across and about one-third lit.

Only **Mars** remains invisible this month. It passes behind the Sun from our viewpoint June 14.

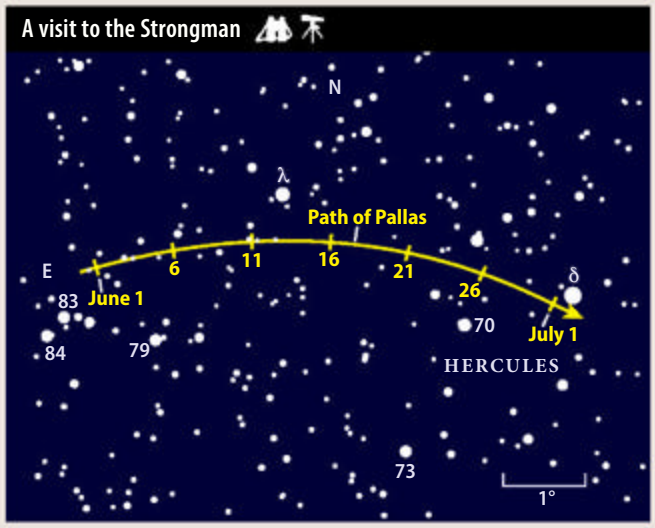
LOCATING**ASTEROIDS**

Play it again, Pallas

Asteroid 2 Pallas stands out from the family of asteroids like a black sheep. Unlike most main-belt objects, Pallas' orbit inclines steeply to the plane of the solar system. (Of the first 1,000 asteroids discovered, Pallas' 35° inclination is the highest.) A big impact likely kicked it into this odd orbit.

Pallas reaches opposition and peak visibility June 11, though it's easy to find through binoculars or a telescope all month. It glows at 9th magnitude among the background stars of Hercules, a region already halfway to the zenith in the eastern sky as night settles in. Use the StarDome map at the center of the magazine to zero in on magnitude 3.1 Delta (δ) Herculis, your jumping-off point for finding Pallas.

You can hop quickly to Pallas June 12–14 when it passes 33' (just over one Full Moon diameter) south of magnitude 4.4 Lambda (λ) Her. The asteroid will be even easier to find June 30 when it pulls within 26' of Delta Her. You can detect Pallas' motion in a four-hour observing session June 3, 5, 7, and 11 when background stars provide a convenient framework.



Pallas reaches its peak at opposition June 11, though the 9th-magnitude asteroid will be easy to spot all month among the stars of Hercules.

GET DAILY UPDATES ON YOUR NIGHT SKY AT **www.Astronomy.com/skythisweek.**

WorldMags.net

BLAST RADIUS

Q: HOW CLOSE COULD YOU BE TO WITNESS ARIZONA'S METEOR CRATER FORM AND STILL LIVE TO TELL THE TALE?

Matthew Petty, *Scotts Valley, California*

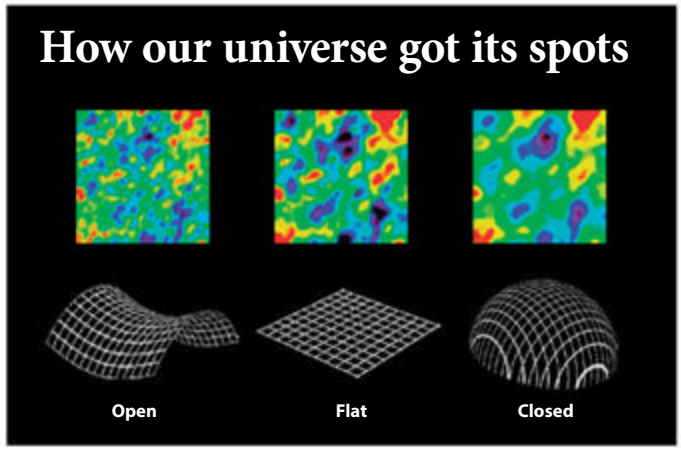
A: If the Barringer Meteor Crater impact event in Arizona occurred in a modern city, it would completely destroy it. As the question implies, distance from the point of impact is directly related to one's survival. The key to determining a safe distance lies in the energy of the impact event. Estimates of that energy exist, but the range of uncertainty can have significant consequences. If the energy was sufficiently small, one could have had a spectacular view of the impact event from Anderson Mesa, a long volcanic ridge about 15 miles (24 kilometers) west of the crater. However, for some of the larger energy estimates, that location may have been uncomfortably close, if not deadly. I have often thought that a very nice — and safe — vantage point would have been Mount Elden, a towering volcanic dome in Flagstaff nearly 40 miles (60km) northwest of the crater.

The impact produced a shock wave and air blast that radiated across the landscape. If the impact energy was 20 megatons, it was immediately lethal for human-sized animals within 4 miles (6km) of the impact. A sharp change in pressure caused by the shock wave produced severe lung damage within 6 to 7 miles (10 to 12 km) of the impact. Winds were also catastrophic, with speeds in excess of 900 mph (1,500 km/h) within the inner 4-mile-diameter zone and still more than 60 mph (100 km/h) at radial distances of 12 miles (20km). Those winds would have picked up debris and hurled it across the landscape like a shotgun blast. Mammoths, mastodons, and giant ground sloths were among the unfortunate victims of the impact event. Let's hope we are able to mitigate future events of that size and larger so that we never have an opportunity to witness them from any distance.

David Kring
Lunar and Planetary Institute, Houston



Barringer Meteor Crater in Arizona formed when an asteroid hit about 50,000 years ago. The blast sent catastrophic winds out at some 900 mph (1,500 km/h) across the immediate area, instantly killing animals unfortunate enough to witness the impact close up. METEOR CRATER



Our universe is freaky flat. How do astronomers know? The cosmic microwave background, which constitutes the oldest light in the universe, would appear different depending on curvature. Through decades of observations, scientists have learned that our cosmos is as flat as a countertop to the extent spacecraft can measure. NASA/WMAP SCIENCE TEAM

Q: HOW DO WE KNOW SPACE IS FLAT?

Dan Vos
Cary, North Carolina

A: We measure how curved space is the same way the Greeks measured the size of Earth: using trigonometry. In this case, the method is known as a "standard ruler test."

If I take a ruler of known length and move it away from me, it subtends a smaller and smaller angle. How rapidly the angle decreases depends on how curved the space is. If I live at the north pole of a sphere and do this, the angle decreases at a different rate than if I do this on a flat sheet of paper. (Sometimes it's easier to visualize this by holding the angle fixed and seeing how big a "ruler" you need, but we do the measurement the other way.)

By using the physics of sound waves in the early universe to define our "standard ruler," we are able to do this test on the largest observable scales with the European Space Agency's Planck spacecraft. In practice, we need several distance measurements to take out confounding effects of other factors (such as how rapidly space is expanding), but in the end, we find that space is flat to the limits of our capability to measure it.

Martin White
University of California, Berkeley

Q: HOW WERE THE CONSTELLATION BOUNDARIES SET? THEY APPEAR PRETTY ARBITRARY.

Robert Bobo
Mckenzie, Tennessee

A: If you think the constellation boundaries look arbitrary now, consider the situation a century ago. No official star chart existed, and those in common use not only set different boundaries for the star patterns but also all had differing numbers of constellations. Some had as few as 70, and others topped out near 100.

Astronomers first formally addressed these problems in 1922 at the initial meeting of the International Astronomical Union. They formed Commission No. 3, headed by Belgian-French astronomer Eugène Joseph Delporte. His task was to scientifically define the constellations and assign their boundaries.

WorldMags.net

Delporte's group finished their study and presented their report in 1928, and two years later the book *Délimitation Scientifique des Constellations, tables et cartes* with the official list and boundaries appeared.

As the commission performed its duties, members incorporated two general rules. First, all of the constellation borders followed lines of right ascension (R.A.) and declination (Dec.), the celestial coordinate system astronomers use. In the 85 years since 1930, however, a long-term motion of our planet called precession has altered the boundaries so that they no longer exactly follow current R.A. and Dec. lines.

Second, the group tried to accommodate the historical shapes of the constellations and not impose a square or rectangular region where it didn't make sense. The legacy we have, then, is 88 figures whose borders follow lines of celestial coordinates and which still make sense historically.

Michael E. Bakich
Senior Editor

Q: WE OFTEN READ OF DISCOVERING EXOPLANETS. HOW FAR AWAY FROM EARTH WOULD WE BE "DISCOVERED" BY ANOTHER CIVILIZATION WITH OUR CURRENT DETECTION TECHNOLOGY?

Tom Connelly, *Chicago*

A: Currently, the most common ways to detect exoplanets are the photometric transit technique, which seeks dips in light due to planets passing in front of their host stars, and spectroscopic observations, which detect radial velocity variations when a planet pulls on its star. Measuring radial velocity shifts for Earth-sized planets with one-year orbits around Sun-like stars is not possible with current technology.

Earth's orbit around the Sun causes a velocity change of only about 1 centimeter per second, whereas the best instruments available today only can produce measured values of about 10 cm/s or larger. Photometric work to search for exoplanet transits from the ground require the brightest stars and can measure brightness variations less than about 1 percent or so, enabling them to detect exoplanets down to about Neptune's size.

Both of these techniques suffer from having to observe through Earth's atmosphere and, if trying to measure a long orbital period such as Earth's, the need to keep tremendous stability in the instrument over extended time periods. Thus, at present, neither of these techniques could detect an Earth-like planet orbiting a Sun-like star at any distance with a ground-based telescope.

NASA's Kepler mission, however, was built just for this specific purpose — to find the frequency of Earth-sized planets in approximately yearlong orbits around Sun-like stars. Kepler discovers exoplanets by measuring the small drop in brightness that occurs when a planet transits the disk of its host star. A planet as small as Earth causes a 0.01 percent drop in brightness while transiting our Sun. This tiny change is the reason these types of measurements only can be made in the stable conditions of space.

If we take Kepler as the best current technology we have, we could detect a planet similar to Earth orbiting stars like our Sun down to a visual magnitude of 12 to 13. Thus, the technology in a mission such as Kepler would allow Earth's detection from as far away as 800 to 1,300 light-years.

Steve Howell
NASA's Ames Research Center, Moffett Field, California



Kepler-186f is the most likely habitable exoplanet candidate yet, but it's not another Earth. Nonetheless, astronomers say current human technology could find our planet from as far as 1,300 light-years away. NASA/SETI/JPL

Q: EVERYTHING AROUND US IS SPINNING: PARTICLES, PLANETS, STARS, GALAXIES. WHY NOT THE UNIVERSE?

Cornel Halmaghi
Maple Ridge, British Columbia

A: Spin is ubiquitous in the cosmos. Planets rotate, as do stars and galaxies. This comes about simply from conservation of angular momentum. When two ice skaters approach each other and link arms, they will start rotating — clockwise if they link right arms and counterclockwise if they link left arms. If two stars approach each other, gravity along with other effects might cause their mutual capture. The associated matter may form planets and other objects that share the original angular momentum and are all likely to rotate or spin with an axis along its original direction. This is a random process, so we would not expect the universe as a whole to have a net angular momentum, unless it had one originally.

Astrophysicists believe the universe started some 13.8 billion years ago in a "Big Bang" that rapidly expanded into the universe we see today. We are confined within that universe, and we can never see what, if anything, is outside it. Still, we can imagine seeing our universe from the outside.

It is possible to visualize our universe spinning in this larger space. Protons were born spinning, as were electrons, neutrinos, etc. Why not universes? If the universe was born with an initial spin, as it expanded from the Big Bang, turbulence would cause the initial angular momentum to dissipate among smaller and smaller objects. In other words, we would not expect the universe as a whole to be rotating now. Instead, the smaller objects like galaxies would "remember" the primordial angular momentum and show a preference for rotating about the original spin axis.

This would show up in the orientation of spiral galaxies as we see them. In fact, there is significant evidence that spiral galaxies do exhibit a preferred spin direction about an axis close to the north pole of our Milky Way. About 10 percent more spiral galaxies are left-handed spirals, spinning in the same direction as our own.

Michael J. Longo
University of Michigan, Ann Arbor

Send us your questions

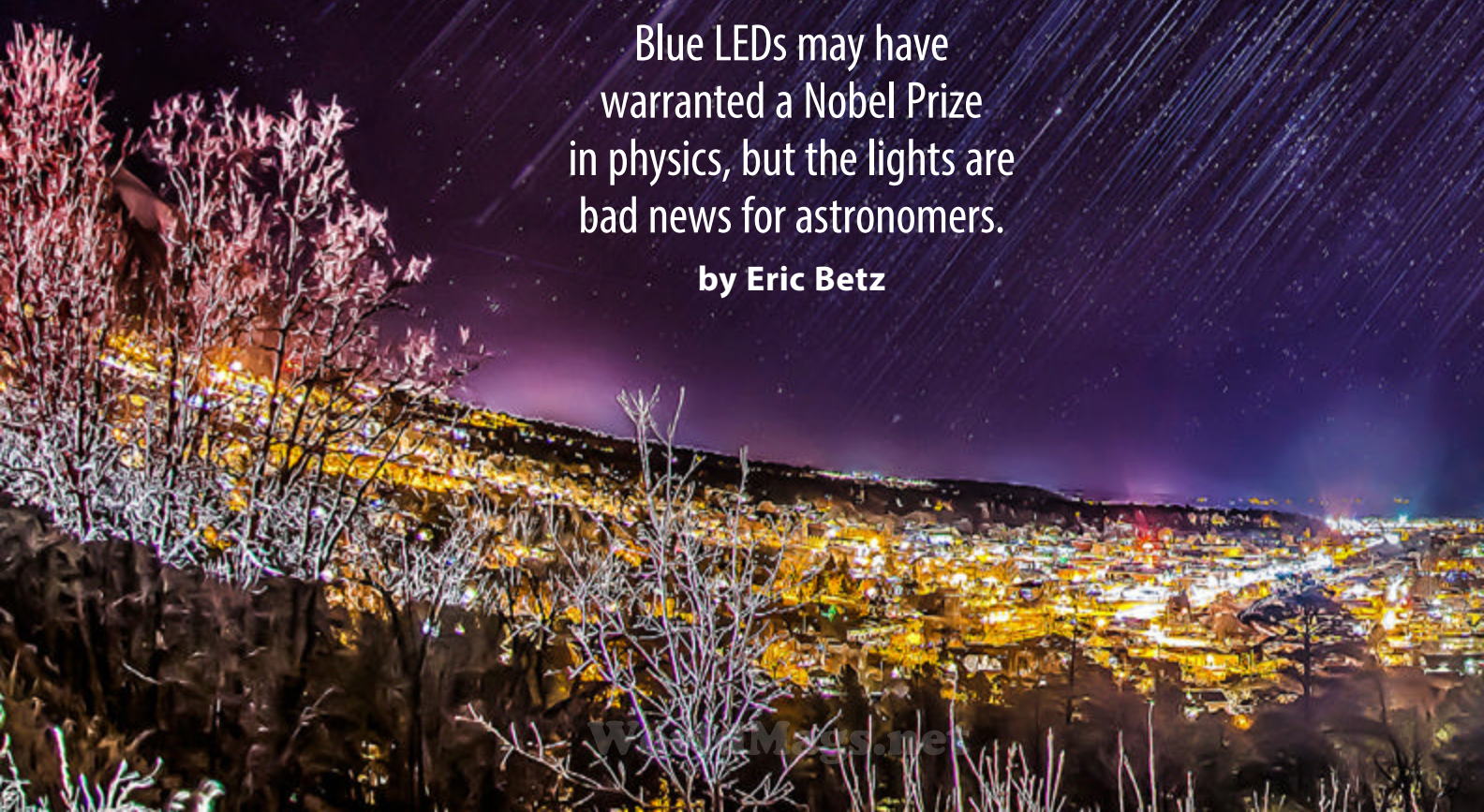
Send your astronomy questions via email to **askastro@astronomy.com**, or write to Ask Astro, P. O. Box 1612, Waukesha, WI 53187. Be sure to tell us your full name and where you live. Unfortunately, we cannot answer all questions submitted.

WorldMags.net

A NEW FIGHT FOR THE NIGHT

Blue LEDs may have warranted a Nobel Prize in physics, but the lights are bad news for astronomers.

by Eric Betz



WeAreMags.net

THE AFTERNOON SKIES WERE clear and blue like countless centuries of others in Chile's Atacama Desert when the blast rang out. The explosion shattered the silence and sent rock high into the thin Andean air. Some 70 controlled detonations would follow, removing millions of cubic feet of dirt to flatten the peak of Cerro Las Campanas for the nearly $1 billion Giant Magellan Telescope.

But this won't be the only high-dollar instrument in the Atacama Desert. Nearby, work has begun on the Large Synoptic Survey Telescope, designed to image the entire visible sky every few nights. To the north, Europeans are constructing their Extremely Large Telescope, which will one day be the world's largest.

Combined with the recently finished Atacama Large Millimeter/submillimeter Array, these projects will cost more than $4 billion. This incredible investment was lured by what is perhaps Chile's greatest natural resource — some of the darkest and driest skies on Earth. In this wasteland, the Milky Way casts shadows, taking its claim as the sky's most distinguishable feature.

But even here this princely sum isn't enough to stop the march of light into one of the last bastions of the night. Cities are expanding alongside tourism and mining. Workers are improving the north-south Panamericana Highway, where the government is building highway security checkpoints with hundreds of LED streetlamps and 15 toll plaza floodlights below telescopes on Las Campanas and nearby La Silla. Outside the Cerro Tololo Inter-American Observatory in La Serena on the Chilean coast, a new mine will operate 24 hours a day and run material directly to port.

Unlike the United States, Chile has a national dark-sky ordinance. Some of these new sites will be in direct violation of the law, but so far, that hasn't stopped their progress.

"We've got some work to do," says Chris Smith, the head of mission in Chile for the Association of Universities for Research in Astronomy. "There are a lot of cheap, not very good lighting fixtures being pushed for, and we're having trouble with LED signs that are going up."



Low-pressure sodium streetlights in Flagstaff, Arizona, cast a yellow hue across the world's first International Dark-Sky City as seen from Mars Hill, home to Lowell Observatory. BRIAN BRADLEY

WorldMags.net



P. HORÁLEK/ESO

The green Comet Lovejoy (C/2014 Q2) passes below the Pleiades and away from the red California Nebula in the skies over La Silla, Chile. Nearby (center right), the Panamericana Highway casts an earthly hue.

Smith worked with the Chilean government in 2013 to craft a new lighting ordinance that limits total light levels as well as electronic billboards. The Chilean president signed the legislation, but bureaucratic holdups have stopped the law's implementation.

Smith says he's now trying to convince Chilean officials that their night sky is a national resource no less important than the minerals coming from the ground.

Around the world, the centuries-old problem of light pollution has been compounded by a sea change in lighting technology brought on by LED lights that spread their radiation across the electromagnetic spectrum. Their light is cheap, efficient, and low maintenance, making conversion an inevitable choice.

New light shields and filters have given astronomers hope that LEDs might become a good thing for dark skies in some communities, but that will require governments to adopt and then enforce aggressive new policies. To solve the new problems, advocates must take on the old.

Taming the blue

This march of progress began in 1882 on the streets of America's largest city. New York — where Thomas Edison unleashed his incandescent revolution of fuses, meters, and bulbs — completed its move from gas streetlights into the era of electricity less than a century ago.

The tens of thousands of lampposts in a stunning variety of shapes and technologies eventually gave the avenues their famous ephemeral glow. The rest of the country followed at a breathtaking pace.

But in homes and on streets, lights progressed relatively little in the many decades since electricity's first revolutionary leap.

That changed in the early 1990s when three Japanese researchers solved a puzzle that had confounded scientists for decades. Isamu Akasaki and Hiroshi Amano of the University of Nagoya, as well as Shuji Nakamura from Nichia Chemicals, wanted to create white LEDs.

Red and green already existed, but scientists had tried and failed to produce a bright blue LED. All three were needed to make a white light.

Laboring in the lab, they found new ways of growing specific crystals and mastered fresh techniques for controlling semiconductors.

The bulbs became ubiquitous, eventually occupying Christmas lights, television sets, and streetlights.

White LEDs now can last 100 times as long as incandescent bulbs and 10 times longer than fluorescent lights. LEDs are also orders of magnitude more efficient, which means low-power solar panels can help bring light to the more than 1 billion people who now live without it.

Los Angeles, which has long been known and loved by Hollywood filmmakers for its yellow-tinged, high-pressure sodium lit nightscape, recently converted its streetlights to LEDs. To the chagrin of some movie buffs, the streets now have a dramatically whiter look. The city's Bureau of Street Lighting — operating under the slogan "Bright Lights, Safe Nights" — swapped in 140,000 LED lights over a four-year period and estimates saving millions of dollars every year. In 2013, New York City announced it would follow suit, putting in a mind-boggling quarter of a million LED streetlights. Small towns and major cities across America are doing the same.

"Their inventions were revolutionary," the Royal Swedish Academy of Sciences said in announcing the 2014 Nobel Prize in physics for the invention of blue LEDs. "Incandescent light bulbs lit the 20th century; the 21st century will be lit by LED lamps."

The nightmare spectrum

The blue LED revolution has many cities converting without a second thought, but scientists say there's good reason to pause.

Before LEDs, new types of bulbs doubled lighting efficiency in the United Kingdom in the second half of the 20th century. Yet the electricity used per person for lighting grew fourfold during the same period. When lights get cheaper, humans tend to use more of them and in new, innovative ways.

For decades, low- and high-pressure sodium lights have been a yellow-hued mainstay in many dark-sky communities





LOS ANGELES BUREAU OF STREET LIGHTING

Los Angeles recently converted from yellowish high-pressure sodium (left) to bright white LED streetlights (right), prompting complaints from some movie buffs fond of the city's distinct nightscape.

Eric Betz *is an associate editor of* Astronomy. *Follow him on Twitter @ericbetz.*

WorldMags.net



New York City, once at the forefront of electricity, is again playing a leading role adopting LEDs. NASA



Light pollution spreads out below Mauna Kea on the Big Island of Hawaii, which will soon be home to the more than $1 billion Thirty Meter Telescope. ANDREW COOPER/W. M. KECK OBSERVATORY

and big cities. These lights confine themselves to a small band of the electromagnetic spectrum that astronomers easily can remove. In contrast, LEDs leave a large footprint across the spectrum. The now common blue bulbs are the worst offender.

Their light falls in what University of Hawaii astronomer Richard Wainscoat calls the "nightmare spectrum."

In lighting, color temperatures above 5,000 kelvin are considered "cool colors," like blue. "Warm colors" such as yellow fall around 3,000 K. Cities are turning to LEDs because of the large potential cost savings; however, the average 5,000 K streetlight emits a large amount of light in the bandwidth around 450 nanometers, where astronomers commonly observe. The light might not be an affront to the eye in an already well-lit area, but for the sensitive CCD cameras used by astronomers around the world, it's blinding.



"The blue light really has to be suppressed; otherwise our view of the night in the future is going to be suppressed," Wainscoat says.

Like other communities around the world, Hawaiian cities are converting to LEDs. On the Hawaiian island of Maui, Wainscoat is worried new city lights might jeopardize the dark skies needed by the instrument he heads, Pan-STARRS.

The wide-angle telescope has the world's largest CCD camera and rapidly scans the entire visible sky in search of asteroids and comets in Earth's vicinity. A recent record-breaking night netted 19 asteroids — two that approach our orbit — in one run.

And, like Chile, it's not just science at risk. An economic impact study by the University of Hawaii estimated that about $168 million was spent on astronomy in the islands in 2012, creating some 1,400 jobs.

Laws not enforced

Hope lies across the water on Hawaii's Big Island, home to the world-famous dark skies of Mauna Kea, where officials plan to update their lighting ordinance this year. New LED streetlights there have filters that remove the blue light. Full-cutoff light shields make sure the light points at the ground instead of up and out, which spreads light pollution. Warmer amber-filtered LEDs would be better for astronomy, but the technology is still far too expensive.

"On the positive side, retrofits with LEDs present the opportunity to replace poorly shielded lights with fully shielded lights," Wainscoat says. "Anyone with any interest in astronomy should stay very vigilant about this — to make sure that only fully shielded LEDs are installed."

That's not happening now outside the public sector. "Enforcement of the ordinance is quite lax," Wainscoat says. "A Jack In The Box [restaurant] on the Big Island is treated like a Jack In The Box anywhere else."

The problem is worse away from the major dark-sky sites, where relatively few residents are pushing cities to shield new LEDs and cities aren't enforcing existing laws. Even many astronomers are not yet on the bandwagon. At the most recent American Astronomical Society meeting in Seattle — the so-called "Super Bowl of astronomy" — a session on light pollution drew mostly empty chairs.

Daniel Caton, director of observatories at Appalachian State University in North Carolina, told those in attendance that he's generally disappointed at the lack of protest by astronomers in their hometowns.

"It's fine to go off to Mauna Kea or Cerro Tololo, but when you get home, you have to live with it," Caton says. "Eventually, these orange bubbles of sodium vapor light are going to overlap."

A white-light night

In 2010, German researchers found that light pollution's global reach is expanding by 6 percent each year with understudied but very real impacts on biology. Some 30 percent of vertebrates are nocturnal, and that number doubles for invertebrates. Ecologists worry about species like moths and bats — nighttime pollinators that many plants depend on.

Other scientists think entire ecosystems could be at risk. Recent studies with light traps in New Zealand found insects

WorldMags.net



ASTRONOMY: ROEN KELLY

Research shows that even partial shields on streetlights cause substantial glare. Full shielding casts light straight down and confines it to the immediate area.

were 48 percent more attracted to LED lamps, regardless of bulb color, than they were to high-pressure sodium bulbs. They concluded that the new technology will create a "white-light night" that increases the ecological impact of light pollution.

And humans aren't immune either. Breast cancer studies have found that tumor growth accelerates when artificial light disrupts the circadian clocks of our 24-hour day and night cycle. That process controls as much as 15 percent of human genes, which leads researchers to suspect other ill effects from photons falling on human retinas at night. A report put out by the American Medical Association even recommends reducing light pollution, limiting shift work, and avoiding excessive nighttime exposure to electronic media.

The psychological impact is harder to quantify. Scientists can't put numbers on what happens when millions of children are raised in interconnecting light bubbles with little reason to look up. *The First World Atlas of the Artificial Night Sky Brightness* in 2001 showed two-thirds of Americans and half of Europeans can no longer see the Milky Way. In fact, after the 1994 Northridge earthquake knocked out power in Los Angeles, many residents called emergency lines to report a "giant, silvery cloud" in the night sky.

The dark-sky gospel

James Lowenthal is a self-described global warming evangelist. He's also an astronomy professor at Smith College in Massachusetts, where many residents hold similar environmental views.

One night, Lowenthal was riding his bike home when the glaring lights of new housing at a recently redeveloped psychiatric hospital site caught his eye.

"I was confident because of the good lighting ordinance I had helped pass, any new development would comply," Lowenthal says. That was not the case.

He took photos of the noncompliant lights and showed them to the city council. His images drew gasps from the elected officials.

He discovered the developers had told city planners they wanted to give their buildings a "village feel" and gained approval to install acorn-style streetlamps for acres and acres. When confronted with the illegality of their lights, the developers pointed out that the manufacturer had stamped "dark-sky rated" on the product.

"It's definitely not full-cutoff," he says. "It doesn't satisfy any of the requirements of the board's own code, but because it said 'dark-sky rated,' they approved it."

"Every planning board in the country must be dealing with this," Lowenthal says. "They're overworked. It's very easy for things to slip through the cracks."



Unshielded lights illuminate a parking lot of patrol cruisers — and the sky above — at the police department in Northampton, Massachusetts. The city's lighting ordinance requires shielding. JAMES LOWENTHAL

The problem has gotten worse for advocates. Northampton appointed an energy officer to monitor efficiency, and he's pushing for LED streetlights to be installed around town. The 2006 lighting code says nothing about the new technology.

Lowenthal decided to fight for changes to the code he helped pass. But his fight has been acrimonious in the small town. He's met resistance while pointing to research that shows excess lighting can negatively impact human health and disturb wildlife while having little effect on public safety.

The astronomer gave a presentation to Northampton's city council in 2014 and pushed for shielding requirements on new LEDs and a lighting curfew that would force businesses to stop lighting empty parking lots at night. He gathered 40 signatures for a "Starry Skies" petition. The city's police chief, Russell Sienkiewicz, stood up in opposition during the meeting, saying that lighting is the second most important tool police have, behind more patrols.

"I would ask just for you to consider if good lighting is important," the chief said, according to the *Daily Hampshire Gazette*. "If you're a nurse or a clerk working late and you have to walk in a dark parking lot because you are [a] half-hour behind when a business is closed, would lighting be good for you? Would you feel comfortable?"

To his frustration, Lowenthal says even the police headquarters has illegal lighting, installed as a result of a recent overhaul.

He hopes municipalities can learn from the example of Davis, California, where a relatively small group of citizens recently showed they could have an impact.

Following a pilot project that went unnoticed, the central California town

WorldMags.net



Light pollution's reach increases by 6 percent each year, leading researchers to predict that only a few patches of truly dark skies will soon exist in the U.S.
MARC IMHOFF/NASA GSFC/CHRISTOPHER ELVIDGE/NOAA NGDC (DATA); CRAIG MAYHEW AND ROBERT SIMMON/NASA GSFC (IMAGE)

moved forward with plans to replace 2,600 streetlights with LEDs at a cost of about $1.2 million. Over the course of 15 years, the city council anticipated saving more than three times their initial investment, much of which was offset by federal grant funds. It wasn't until workers installed the LED lights across most areas of Davis that the complaints started streaming in.

Residents said they hated the glare, the color, and losing the night sky. Enough people complained that Davis suspended the project and is now looking at alternatives. Lowenthal says officials should take note that it's much more expensive to replace streetlights twice.

"If the public rejects your plan, what are you going to do?" he says.

Dimming the desert

A similar battle has been brewing in Arizona. In Flagstaff, signs posted at city limits proudly declare the mountain town as the world's first "International Dark-Sky City." Percival Lowell built his observatory here more than a century ago atop Mars Hill, which now overlooks a city of about 60,000 people. The town is also home to the U.S. Navy's astronomy facilities.

In 2014, a developer tried to gain approval for a 714-bed student housing project right next to the Naval Observatory. The design did not violate the city's dark-sky ordinance, but doubled lighting near the facility, which also sits near Lowell.

The Flagstaff City Council approved the project despite a uniformed naval captain's briefing on the observatory's importance to America's defense. Hundreds wrote in protesting the development, and the project went down in defeat after nearby residents rallied a petition that forced a new vote backed by a supermajority of the council. The developer withdrew its request.

"This was very difficult to fight, probably because the developer said, 'You set the rules; we're following them,'" says Lowell Observatory Director Jeffery Hall. "I don't want to just be an ogre using the ordinance as a hammer."

Like chopping the head off the hydra, Hall doubts this development will be the last to challenge Flagstaff's dark skies. And the next threat already may be on the horizon. Long a major consumer of low-pressure sodium lights — the most dark-sky-friendly technology available — Flagstaff too is now testing a conversion to LEDs. The move took astronomers by surprise, and officials were similarly taken aback by the astronomers' protests. "Even our code is not ready to adapt to the recent changes in LED technology," Hall says. The debate prompted Lowell to host a conference on LEDs and light pollution last year and invite industry and government officials, as well as astronomers.

Lori Allen, who directs Kitt Peak National Observatory outside Tucson, Arizona, attended the conference because her facilities have seen the same problems. Kitt Peak has faced a funding crisis in recent years as it vies for cash with more modern instruments built in increasingly remote locations. NASA and the National Science Foundation only recently eased Allen's concerns by committing to pay for new instruments to carry out long-term projects on the mountain.

Growth across her border city has been swift, but Allen says the observatory's main foe lies farther away. Photos of sky glow captured since the 1950s predictably show Tucson's light bubble increasing, but at an amount that pales in comparison to the spread of Phoenix more than 100 miles (160 kilometers) away. Amazingly, a 2010 study found that Kitt Peak's dark skies were relatively constant going back to the 1970s due in large part to strict lighting ordinances. But as the city of Tucson begins converting to LED streetlights, it too must find a way to incorporate the new technology into existing regulations or risk losing night skies.

"All these cities are looking at these LEDs and seeing huge savings," Allen says. "We're not dead yet, and we've got some exciting projects over the next few years. We have a very bright future at Kitt Peak if we can keep the dark."

WATCH THE INTERNATIONAL DARK-SKY ASSOCIATION'S SHORT DOCUMENTARY, "LOSING THE NIGHT," AT **www.Astronomy.com/toc.**

WorldMags.net

Explore the Antares region

This summer, discover the spectacular area around one of the sky's brightest stars. **text by Michael E. Bakich; image by Tony Hallas**

AS JUNE ROLLS AROUND, observers north of the equator think less about galaxies and more about what they want to target as the center of the Milky Way rises into prominence. Pointing a telescope in the vicinity of reddish Antares (Alpha [α] Scorpii) is a great start, but do plan to spend some time scanning the sky here because there's a lot to see. Emission and reflection nebulae intermix with star clusters, and a wider view shows numerous areas of dark nebulosity — seeming gaps in the sky that conceal the stars and brighter gas behind them. To help you navigate this region, we've prepared this guide based on the marvelous image by Tony Hallas. You might want to point your camera toward this field. If you get something you're happy with, send it with all the details to me at readergallery@astronomy.com. You never know.

Michael E. Bakich *is a senior editor of* Astronomy. **Tony Hallas** *is a contributing editor and a noted astroimager who hails from Foresthill, California.*

WorldMags.net




B45
B44
LBN 1105
σ Scorpii
IC 4605
22 Scorpii
Cederblad 130
NGC 6144
IC 4606
M4
Antares Reflection Nebula
Antares
Antares Emission Nebula
Astronomy magazine

FIRST LOOK at the 2017 TOTAL ECLIPSE

Excitement is building for the first total solar eclipse in the U.S. in 26 years. **by Michael E. Bakich**

A small percentage of people have experienced a total solar eclipse. Even fewer have seen one from the air. The photographer and some friends chartered a Dassault Falcon 900B jet from Bermuda to observe and record the November 3, 2013, event. BEN COOPER/LAUNCHPHOTOGRAPHY.COM

Drama is coming to the U.S. On August 21, 2017, Sun-watchers along a line from Oregon to South Carolina will experience nature's grandest spectacle: a total solar eclipse. It's likely to be the most viewed sky event in history. That's why even now, some 800 days before the eclipse, astronomy clubs, government agencies, cities, and even whole states are preparing for the unprecedented onslaught of visitors whose only desire is to experience darkness at midday.

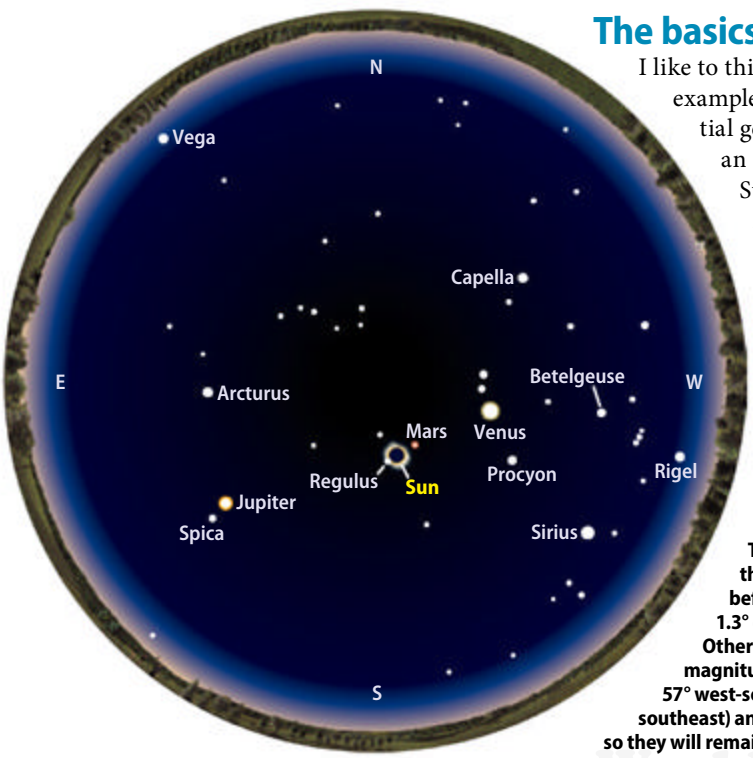
This will be the first total solar eclipse crossing the continental U.S. in 38 years (totality touched Hawaii on July 11, 1991). The last one occurred February 26, 1979. Unfortunately, not many people saw it because you had to be in (or travel to) a narrow path crossing one of just five states in the Northwest, and that winter's weather for the most part was bleak along the path of totality. Before that eclipse, you have to go back to March 7, 1970, a total solar eclipse that moved up the East Coast, again occurring in a scant five states.

The basics

I like to think of total eclipses as examples of sublime celestial geometry. Each one is an exact lineup of the Sun, the Moon, and Earth (for a total solar eclipse) or the Sun, Earth, and the Moon (for a total lunar eclipse). And although total solar eclipses occur more often than total lunar ones, more people — actually, pretty much everyone — has seen a total eclipse of the Moon. Few, on the other hand, have seen a total solar eclipse.

The reason is quite simple: We live on Earth, and it's our perspective that interacts with the geometry of these events. During a lunar eclipse, anyone on the night side of our planet under a clear sky can see the Moon passing through Earth's dark inner shadow. That shadow, even as far away as the Moon, is quite a bit larger than the Moon, so it takes our satellite some time to pass through it. In fact, if the Moon passes through the center of Earth's shadow, the total part of the eclipse can last as long as 106 minutes. Usually totality doesn't reach that duration because the Moon passes either slightly above or below the center of the shadow our planet casts.

Conversely, the Moon and its shadow at the distance of Earth are much smaller; so small, in fact, that the shadow barely



This sky chart shows the Sun near the time of greatest eclipse along with some of the bright celestial objects you may be able to spot during totality. The Sun stands before the constellation Leo the Lion. Magnitude 1.3 Regulus (Alpha [α] Leonis) lies 1.3° east of the Sun, where sharp-eyed observers under a perfect sky may spot it. Other objects to look for are magnitude –4.0 Venus (36° west-northwest of the Sun), magnitude –1.8 Jupiter (51° east-southeast), magnitude –1.5 Sirius (Alpha Canis Majoris, 57° west-southwest), and magnitude 0.1 Rigel (Beta [β] Orionis, 61° west). Mercury (10.5° southeast) and Mars (8.3° west-northwest) will glow at magnitudes 3.3 and 1.8, respectively, so they will remain invisible. *ASTRONOMY:* RICHARD TALCOTT AND ROEN KELLY

WorldMags.net

reaches our planet's surface. Anybody in the lighter outer region of the shadow (which astronomers call the penumbra) will see a partial solar eclipse.

The lucky individuals under the dark inner shadow (the umbra) will *experience* — a much better word than "see" — a total solar eclipse. Sometimes, only the Moon's penumbra falls on Earth, and the eclipse is partial everywhere. Not in August 2017.

A question people often ask is, "Isn't the Sun a lot bigger than the Moon, so how does the Moon cover it so exactly?" Yes, the Sun's diameter is approximately 400 times larger than that of the Moon. What a coincidence that it also lies roughly 400 times farther away. This means both disks appear to be the same size.

Regarding timing, all solar eclipses happen at New Moon. Unless the Moon lies between the Sun and Earth, it can't block any of our star's light. The only lunar phase when that happens is New Moon.

But why doesn't a solar eclipse happen at every New Moon? The reason is that the Moon's orbit tilts 5° to the plane formed by Earth's orbit around the Sun, which astronomers call the ecliptic (because that's the only place eclipses can occur).

Most of the time, our satellite is either north or south of the ecliptic. But during each lunar month, the Moon's orbit crosses that imaginary plane twice. Astronomers call these intersections nodes.

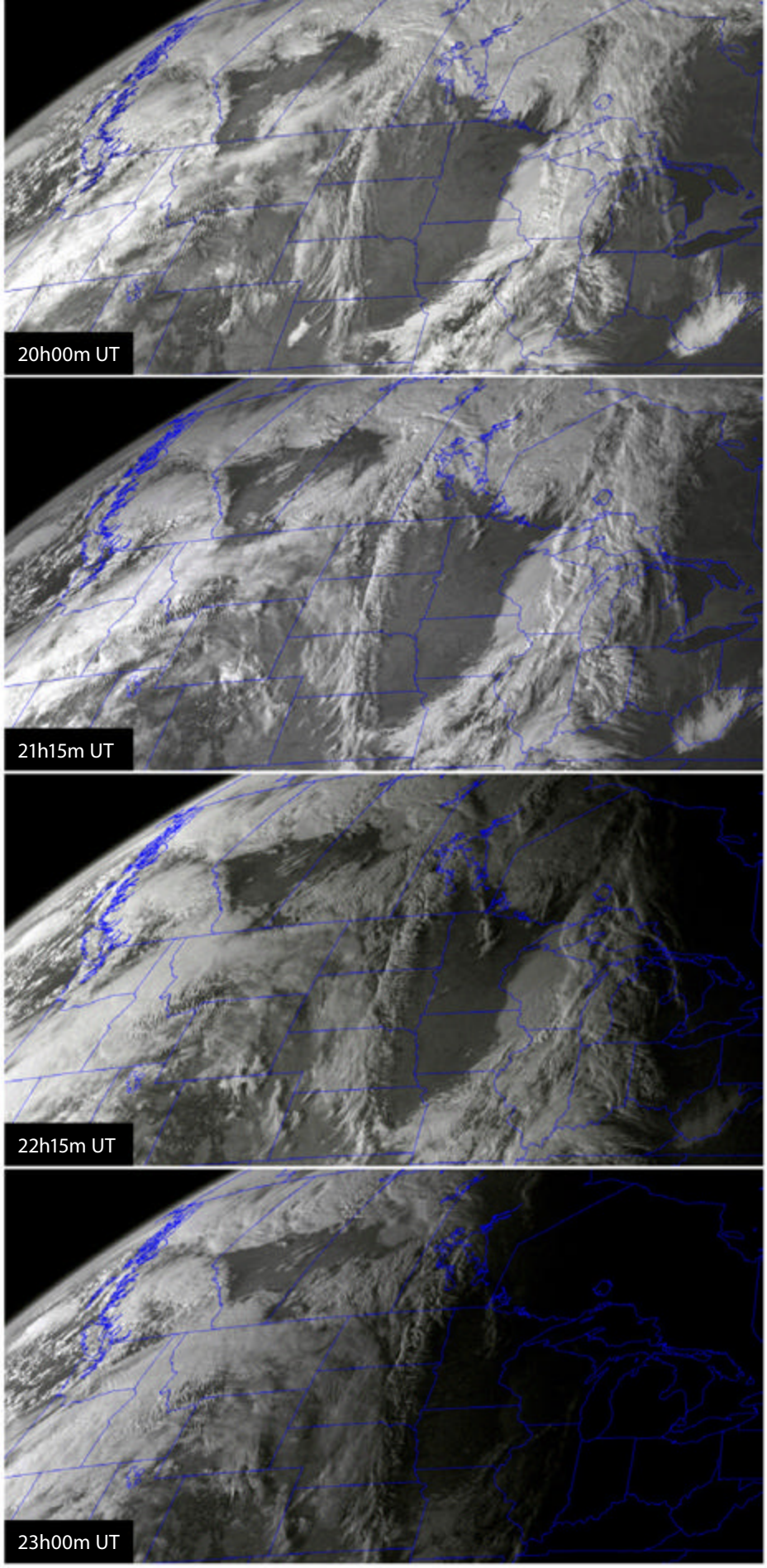
Solar eclipses only occur when the Sun and the Moon lie at the same node. Unfortunately, during most lunar months, the New Moon lies either above or below one of the nodes when the Sun is there, and no eclipse happens. On average, a total solar eclipse occurs somewhere on Earth about once every 16 months.

But the average length of time between two total solar eclipses at a specific location on Earth is much longer: 330 years in the Northern Hemisphere and 550 years for locations south of the equator.

The difference between the hemispheres is due to two factors: 1) More eclipses occur during summer months (more hours of daylight); and 2) the Northern Hemisphere lies farther from the Sun during its summer, making our daytime star a smaller target (hence, easier to cover).

The maximum length of totality also varies from one eclipse to the next. The

Michael E. Bakich *is a senior editor of* Astronomy. *He will be conducting a massive public viewing party for the eclipse in St. Joseph, Missouri. See www.fpsci.com for details.*



The 13th NOAA Geostationary Operational Environmental Satellite took this series of images during the partial solar eclipse October 23, 2014. The shadow moved over Alaska, western Canada, and the far northwestern United States. NASA/NOAA/SSEC

WorldMags.net



The path of the Moon's umbral shadow across land begins in Oregon and ends in South Carolina. Numerous large cities lie within easy reach of the center line. The longest duration of totality — 2 minutes and 41.6 seconds — occurs in and around Giant City State Park, in Illinois. *ASTRONOMY:* ROEN KELLY

reason comes from the fact that Earth is not always at the same distance from the Sun and the Moon is not always the same distance from Earth. The Earth-Sun distance varies by 3 percent and the Moon-Earth distance by 12 percent.

The result is that the Moon's apparent diameter can range from 7 percent larger to 10 percent smaller than the Sun. A bigger apparent size for the Moon and a smaller one for the Sun equals a longer totality. But a Moon that looks smaller and a Sun that appears larger means that you'll experience a shorter time in the dark.

According to Belgian astronomer Jean Meeus, the maximum duration of totality from 2000 B.C. to A.D. 3000 is 7 minutes and 29 seconds. That eclipse will occur July 16, 2186, so don't get too anxious.

The length of totality during the August 21, 2017, eclipse won't be nearly that long.

Its duration will vary according to your location. Where the Moon's umbra first touches land, at Government Point, Oregon, totality lasts 1 minute and 58.5 seconds. The maximum duration, 2 minutes and 41.6 seconds, occurs just south of Carbondale, Illinois.

It's all about totality

Everyone in the contiguous U.S. will see at least a partial eclipse. In fact, if you have clear skies on eclipse day, the Moon will cover at least 48 percent of the Sun's brilliant surface. And that's from the northern tip of Maine. But although our satellite covering part of the Sun's disk sounds cool, you need to aim higher.

Likening a partial eclipse to a total eclipse is like comparing almost dying to dying. If you are outside during a solar eclipse with 48 percent coverage, you won't even notice it getting dark. And it doesn't matter whether the partial eclipse above your location is 48, 58, or 98 percent. Only totality reveals the true celestial spectacles: the two diamond rings, the Sun's glorious corona, 360° of sunset colors, and stars in the daytime. But remember, to see any of this, you must be in the path.

That said, you want to be close to the center line of totality. The fact that the Moon's shadow is round probably isn't a revelation. If it were square, it wouldn't matter where you viewed totality. People across its width would experience the same duration of darkness. The shadow is round,



As totality was ending July 22, 2009, this imager captured three exceptionally nice Baily's beads, which form when light from the Sun's disk passes through valleys on the Moon's edge. BERT HALSTEAD

however, so the longest eclipse occurs at its center line because that's where you'll experience the lunar shadow's full width.

Yes, we're sure

This event will happen! As astronomers, some of the problems we deal with are due to the uncertainty and limited visibility of some celestial events. Comets *may*

WorldMags.net



Whether you observe the Sun with or without a telescope, you must use an approved solar filter. Here, the author's wife, Holley, attached a filter to the front of the telescope. MICHAEL E. BAKICH

appear bright if their compositions are just so. Meteor showers *might* reach storm levels if we pass through a thick part of the stream. A supernova as bright as a whole galaxy *may* be visible, but you need a telescope to view it. In contrast to such events, this solar eclipse will occur at the exact time astronomers predict, along a precisely plotted path, and for the lengths of time given. Guaranteed. Oh, and it's a daytime event to boot.

After the 2017 event, the next total solar eclipse to track across the continental U.S. occurs April 8, 2024. It's a good one, too. Depending on where you are (on the center line), the duration of totality lasts at least 3 minutes and 22 seconds in eastern Maine and stretches to 4 minutes and 27 seconds in southwestern Texas.

After that eclipse, it's a 20-year wait until August 23, 2044 (and, similar to the 1979 event, that one is visible only in Montana and North Dakota). Total solar eclipses follow in 2045, 2052, and 2078.

But it's 2017 that's causing all the excitement now. Stay tuned to *Astronomy* and Astronomy.com for much more information about this event. Future stories will discuss trip planning, how to observe the event, top locations for activities and viewing, and much more. We'll keep you informed so that you can approach the eclipse without a shadow of doubt.



This photo is a digital multiple-exposure of the sequence of the November 14, 2012, total solar eclipse beginning shortly after sunrise as seen from Queensland, Australia. BEN COOPER/LAUNCHPHOTOGRAPHY.COM

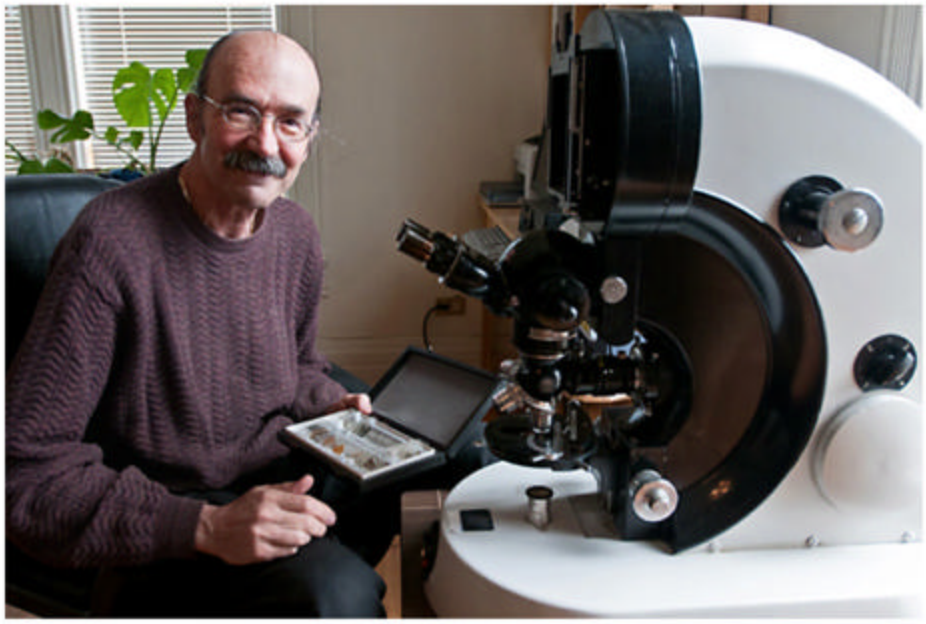


The two most exciting words in science may be, "Diamond ring!" This shot, taken at the beginning of totality July 11, 2010, shows why that phenomenon received its popular name. LES ANDERSON

WorldMags.net

To catch a shooting star

A renowned meteorite hunter turns his gaze to the sky as part of a growing network of fireball trackers. **by Eric Betz**



TAYLOR MAHONEY

Steve Schoner processes meteorites in his office, the former home of Pluto discoverer Clyde Tombaugh.



Steve Schoner once spent 17 years looking for a single rock. He criss-crossed thousands of miles in hundreds of days walking the area around Glorieta Mountain in New Mexico. Along the way, he fell down a cliff, was confronted by a bear, hid from drug smugglers in the dark, and saw more rattlesnakes than he could count.

Most of the time, he hiked alone, watching the ground and listening for telltale beeps from a metal detector — sounds he hoped would lead him to a 40-pound (18 kilograms) asteroid remnant richly laden with yellow-hued stones.

Eric Betz *is an associate editor of* Astronomy.

Schoner was among the most prolific meteorite hunters in the Southwest from the early 1970s until a rare brain disease nearly claimed his life in 2003. He searched for then what he still searches for now: billion-year-old chunks of space rocks left over from the chaotic upstart of our solar system. His slow uphill climb from disability now forces him to hunt meteors with a computer screen and an automated rooftop camera instead of wandering alone in a remote wilderness. The instrument is part of a growing network of fireball video recorders, which use black-and-white wide-angle cameras to capture the entire sky when triggered by celestial movement. These devices are giving astronomers new insights into Earth's interactions with the space debris that surrounds us.

Cosmic dust

A meteoroid spends billions of years drifting about the solar system — either as part of a comet or asteroid, or even a chunk of the Moon or another planet — before it crosses paths with Earth and is violently ripped apart in the atmosphere. Rare martian rocks can be as young as a few tens of millions of years old, but common meteorites (the term for a space rock once it's landed on Earth) are time capsules of planetary infancy dating back some 4.5 billion years.

Small bits of rock are falling to Earth all the time. Estimates vary, but

WorldMags.net



The Chelyabinsk fireball lit up the skies over Russia in 2013. Asteroid expert Mark Boslough and colleagues used witnesses' photos to re-create its path in this digital rendition made on a supercomputer.
3-D SIMULATION: M. BOSLOUGH AND B. CARVEY; TAIL COMPOSITE: A. CARVEY; IMAGE: O. KRUGLOVA/SANDIA NATIONAL LABS

measurements indicate that thousands of pounds of these meteoric debris breach our atmosphere each day and find their way to the surface, where their organics play a role in earthly biology. Most of this cosmic dust is too small to create meteors. Sometimes the rocks are large enough to put on a show. Astronomers call these night-sky streakers "fireballs" when they flare brighter than Venus.

And that's the information New Mexico State University scientists are after. As the number of meteor observations increases, their All Sky Camera Network aims to create overlapping fields of view so that several cameras can catch the same fireball, allowing astronomers to find its speed and height. With sufficient imaging, researchers can calculate the meteor's original orbit and help determine whether the object began life as a comet or an asteroid.

"They're hauling butt, so they've got a lot of energy," says Bill Cooke, who runs NASA's Meteoroid Environment Office at the Marshall Space Flight Center in Alabama. "A lot of people underestimate the amount of energy meteors have." While an average fireball is typically about a millimeter to a centimeter in size, it's entering Earth's atmosphere at anywhere from 25,000 mph (11 km/s) to 160,000 mph (72 km/s).

"If that hits you, it's like I shot you with a .357 magnum," Cooke says. "That's why we worry about orbiting debris so much. A particle smaller than a millimeter can go right through a space suit."

Part of the network's initial funding and goals also stem from a desire to show the U.S. government's satellites how to tell the difference between natural and man-made atmospheric explosions. In some cases, it even can help meteorite hunters like Schoner track down the rock if it survived the fall.

Shooting star survey

Schoner has been involved with this network from his home in Flagstaff, Arizona, since 2012. And his camera isn't just mounted on any rooftop; this is the former home of Pluto discoverer Clyde Tombaugh. So far, Schoner has caught five

WorldMags.net



NASA's fireball cameras can capture the entire night sky in one view, which helps tie events together using instruments around 50 miles (80 kilometers) apart. The cameras are composed of a wide-angle video recorder and a fan to prevent fogging. BILL COOKE/NASA

fireballs. He hopes data from one event will help hunt down the meteorite.

Astronomers have labored to enlist a network of 100 rooftop cameras on homes across the country to watch for meteors, but due to recent budget cuts, the program was shifted to private servers. The data is still collected and stored for research and coordinating meteor fall trajectories, but it's now run by a collaboration between amateurs and professionals.

NASA runs its own search called the All Sky Fireball Network.

Cooke commands that project. He currently has 15 cameras in use, and if he can find the funding, he'd like to implement many more. Whereas the All Sky Camera Network struggled because it relied on the user's computer, Cooke provides citizen scientists with all the equipment needed, installs it, and then performs regular calibrations to make sure the measurements are precise. It's highly effective and produces better science but also much more time-consuming. In addition, he runs a companion effort with 14-inch Celestron telescopes pointed at the crescent Moon to watch for meteor flashes. "We can see a rock the size of a golf ball hitting the Moon with an amateur telescope on Earth," Cooke says. It turns out the impacts correlate well with meteor showers on Earth.

His scopes caught 21 flashes on the Moon in one night during the Geminid meteor shower in December 2010. He says the overall effort is teaching astronomers about the meteoric environment.

And as NASA's network expands, Cooke hopes to catch meteorites from the Taurids and Geminids. Meteors from those two showers are the only ones to breach Earth's atmosphere slowly enough to survive all the way to the ground. Most storms of shooting stars stem from comet debris crossing Earth's path; the Geminids are unusual because they come from an asteroid, 3200 Phaethon, which passes uncomfortably close to our planet.

But what's stranger still is that comets create shooting stars thanks to icy debris; astronomers don't know how an asteroid could pull off such a show. One thought is that Phaethon started life as a comet, which is supported by its highly elliptical orbit.

"Each year I look forward to these events that we might have a potential meteorite dropper," he says. "The science value of that would be potentially immense. It's kind of like a sample return mission, but it's coming to us."

And the project has another even broader objective: informing the public. "We live in a world of 24/7 news, and if people see a bright light, they expect NASA to know what that is," Cooke says. NASA often sends fireball footage to CNN and local TV stations following bright events.

The Glorieta pallasite

As a teenager, Schoner developed a love for meteorites that would lead him to find hundreds of space rocks across the United States and abroad. His mother bought him his first meteorite as a birthday present in 1969. The young Schoner read a news story and contacted a hunter in Australia after residents in the town of Murchison watched a large fireball fall from the sky. He wanted to buy a piece. His father instead insisted he save his dollars for college. But when he returned home for spring break, his mother presented him with a package postmarked from Australia.

"It was wrapped up in a twisted cellophane bag, and when I opened it up, I could smell the organic material oozing out of the meteorite," Schoner says.

She'd bought the carbonaceous chondrite for $7 a pound. (On eBay, thin sections from the Murchison meteorite now sell for hundreds of dollars per gram.)

The gift emboldened Schoner, and, like generations of prior meteorite hunters, he set out on his own expeditions, combing the ground in known fall paths and speaking to locals when an object was actually seen falling from the sky. But he eventually found that even when you know the area where the meteorite fell, it can take years of searching to find what you're after.

"Parting with that big pallasite was a mental trauma for me, even though it is only a big glorious rock. I labored for years, walking untold miles to find it," Schoner says.



Steve Schoner combed a known fireball fall path for 17 years before he found this 44-pound (20 kilograms) meteorite. STEVE SCHONER

WorldMags.net

At Glorieta Mountain, Schoner kept coming back because he believed his Holy Grail stone was out there. He was hunting a 40-pound chunk of pallasite that his mentor, meteor expert Harvey Nininger, first predicted should exist in the late 1930s. Whereas most meteorites are stony or iron, a pallasite comes from the boundary between an asteroid's core and its surface. A pallasite has a rugged exterior, but when cut open, the stones show off like a gem, revealing brightly colored olivine crystals embedded throughout.

In fact, hundreds of pounds of large meteorites had been pulled from Glorieta Mountain starting in 1884, but most were iron. Based on their composition, Nininger had told the then teenage Schoner that a large chunk of pallasite — about 40 pounds — should still be waiting in the dirt.

The discovery of a lifetime finally came in 1997. Schoner had picked up a new metal detector and headed out to search for the stone. As he calibrated the instrument, he walked in a small area around his car to test how it responded. Then it went crazy.

Elbow deep under the surface in a small crater-like depression, he found a 44-pound (20kg) meteorite exactly like the one Nininger had predicted. Schoner won't say how much money he got, but only that he sold the stone to the well-known meteorite collector and dealer Darryl Pitt in a partial trade. Pitt took the risk of cutting the pallasite into slices and sold pieces all over the world. The largest section recently sold at auction for $82,000.

"Parting with that big pallasite was a mental trauma for me, even though it is only a big glorious rock. I labored for years, walking untold miles to find it," Schoner says. "I do not have a slice of it, and that is OK, as it is really only a rock — unlike any other rock, though."

For his part, Pitt says the pallasite as well as Schoner are two of the most interesting specimens he's encountered in a long career chasing meteorites.

A fresh fall

Schoner used funds from the meteorite, as well as cash from selling off property he owned in Flagstaff, to buy the Tombaugh house. He moved the small home to a lot at the base of Mars Hill, where the astronomer discovered Pluto. Tombaugh lived there with his wife and young children before moving to the White Sands Missile Range in New Mexico to help the military learn to track projectiles more precisely. Schoner began the renovation process, but not long after, he was hospitalized with profound brain trauma caused by a rare form of encephalitis — inflammation of the brain. Doctors thought he'd be permanently disabled. Schoner fought back and has regained much of his mental acuity, though he still struggles with stamina and simple math that once came easy to him. He makes his living now through his company, PetroSlides, where he creates thin sections of meteorites for researchers and collectors all over the world. He's even had the opportunity to handle rocks from Mars and one potentially from Mercury.

And he gets his fix of meteorite hunting thanks to his rooftop camera. He's caught a handful of fireballs already, but one recent event has Schoner thinking the find of a lifetime might still be waiting.

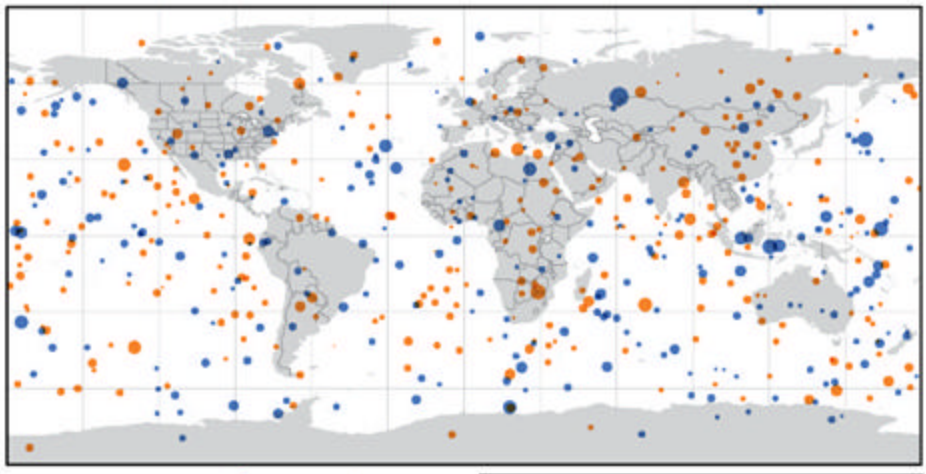
His camera caught a bright fireball October 4, 2014. The bolide lit up the skies over Flagstaff in the early morning hours and left a trail of lingering meteor smoke that mystified local residents, who took their photos to social media. On the sparsely populated Hopi reservation to the north, people said they felt the air shake and the ground move, rattling their windows.

Schoner's rooftop camera was the only one to capture the fireball on video. The instrument wasn't dialed in enough to catch the exact fall path, but Schoner says he has a rough idea where it landed from talking to residents and comparing with online photos. Its likely placement on a Native American reservation means permission is required to search. He plans to mount an effort to find the stone, starting by getting the word out to let locals know what could be strewn across the ground. Schoner rates the rock's potential significance by its "born-on" date, which stands out in his mind.

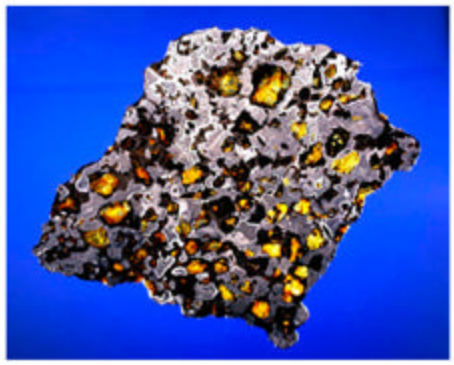
Only 132 Mars meteorites have ever been found. Two fell in early October of different years. Like a meteor shower that returns at the same time each year, Schoner says he has a gut-level feeling that Earth crosses paths with a martian asteroid — a large rock kicked off the Red Planet in an ancient impact — around the same time each year.

Statistically, Cooke says Schoner's expectation of a martian meteorite is highly unlikely to hold up. But after Glorieta Mountain, the space rock hunter has shown that odds don't mean much to him.

Asteroids strike anywhere, anytime



NASA recently released a map of large meteor events, which conclusively shows impacts happen with no trends in location or timing. NASA



This thin section of the 44-pound (20 kilograms) Glorieta Mountain pallasite recently sold at auction for $82,000. COURTESY DARRYL PITT

LEARN ABOUT EFFORTS TO TRACK AND RAISE AWARENESS OF ASTEROID THREATS AT **www.Astronomy.com/toc.**

WorldMags.net

We test Stellarvue's compact refractor

This 2.4-inch scope is so portable that you'll use it night and day. **by Tom Trusock**

Like many observers I've talked to through the years, I always have had a special place in my heart for a small refractor. Refracting telescopes use lenses to bring light to a focus and are the oldest type of telescope. While the inventor of the refractor is a matter of debate, Hans Lipperhey, a German-Dutch spectacle maker, filed the first known patent application October 2, 1608.

Early refractors typically required a large (or slow) focal ratio — which translates to a really long tube — to keep false color under control. Such instruments were a bit unwieldy, especially if there was any wind. Major improvements followed: the achromatic lens (in 1733), the apochromatic lens (in 1981), and various formulas for types of low-dispersion glass.

As amateur astronomers, we are lucky to live in a world where we have a plethora of choices in telescopes. We use them both as camera lenses and visual instruments. Refractors excel at wide fields, but good ones also take magnification well. They are portable, durable, and — when well treated — do not require collimation (alignment). Finally, I prefer a small refractor to large binoculars for one major reason: the flexibility to change magnification.

Tom Trusock *observes regularly despite the often cloudy skies above Ubly, Michigan.*

The tiny titan

Speaking of small telescopes, Auburn, California-based Stellarvue recently introduced a new, ultra-portable apochromatic refractor that I suggest you take a careful look at. If you're an experienced observer, this could become your new grab-and-go scope. If, on the other hand, you're new to astronomy, this scope will help you get into the hobby simply and inexpensively.

The Stellarvue SV60EDS is a 2.4-inch (60 millimeters) refractor that has an apochromatic doublet (two lenses that reduce color) as its objective. Specifications indicate that Stellarvue uses high-quality (FPL–53) glass for one of the lens' elements. The scope's focal length measures 330mm, which yields a focal ratio of f/5.5.

The SV60EDS sports a rotating 2" rack-and-pinion focuser with a dual-speed mechanism. Stellarvue includes a 1¼" adapter, and compression fittings are standard. The scope also comes with a clamshell adapter with finder bracket, a mini Vixen-style dovetail plate, a well-padded soft carry case with room for three eyepieces (or two eyepieces and the optional field flattener), a star diagonal, and a tube extension for those wishing to use the telescope for wide-field photography.

The lens cap is metal and a press fit. The optical tube looks great — white powder coat with black anodized fittings. The telescope, clamshell, and included accessories weigh just 3.8 pounds (1.7 kilograms).

Stellarvue's attention to detail impressed me: The rubber cover on the clamshell lever, the ¼–20 hole in the dovetail plate for direct attachment to camera tripods, and thumbscrews with non-marring tips are all examples of the thought that went into the



Stellarvue's SV60EDS is a compact apochromatic refractor. These images show the telescope fully retracted (left, 8.5 inches [21.6 centimeters]) and extended (12.5 inches [31.8cm]). ALL EQUIPMENT PHOTOS: *ASTRONOMY*: WILLIAM ZUBACK

WorldMags.net



These images of Comet Lovejoy (C/2014 Q2) and the Rosette Nebula show what the SV60EDS can do when connected to a Canon 60Da. The comet image is a two-panel mosaic, each a stack of ten 3-minute exposures at ISO 3200. The Rosette also is a stack of ten 3-minute exposures at ISO 3200. JON TALBOT

telescope design. And the end product is indeed handsome. The big question is: How does it perform in the wild?

Under the sky

With a 330mm focal length, the telescope is its own finder scope. I inserted a 24mm eyepiece with a 68° apparent field of view and enjoyed a magnification of 14x with a true field of view of nearly 5° — that's 10 Full Moons side by side. As you might expect, this leads to some stunning low-power views of the night sky. When picking targets with a small-aperture, low-power scope like this, there is no better starting point than the Moon.

With a waxing gibbous Moon high in the sky and a 3–6mm zoom eyepiece in the focuser, images were sharp and contrasty with little off-axis glare. The telescope had a clear "snap to focus," a trait indicative of high-quality optics. The scope showed little false color even at high magnifications and handled magnification pretty well.

When touring the Moon, I noted on various occasions that the image held up quite well all the way to 110x (46x per inch). In my book, this is a performance consistent with a quality apochromatic doublet. The star test revealed perfect collimation. The images on either side of focus were exactly what I'd hoped to see.

The wide fields this instrument is capable of make for some stunning vistas. Through my 24mm eyepiece, I could see all of Collinder 70 (often called the Orion's Belt Cluster), and the same was true with the entire Orion Nebula (M42) complex. Open clusters were especially beautiful. Their stars shone as gemstones against a deep black background.

My favorite eyepiece with the scope was one with a 13mm focal length that provided slightly more than a 3° true field and offered a magnification of 25x. The combination of wide field, moderate power, and great contrast really served to showcase just how nice this little telescope is.

The SV60EDS also makes a wonderful daytime spotting scope. Its size and capability make it an ideal little telescope to leave set up in the front room of the house for those quick peeks when Mother Nature provides the opportunity.

Apart from my lavish praise, I have only two notes to potential buyers. First, given the scope's small size, it is a bit back-heavy. Depending on your mount (in my case a manual alt-azimuth one), you might want to invest in a slightly longer dovetail plate to allow you to slide the scope forward a bit more and thus obtain a little better balance to facilitate hand tracking.

My second point is for those who may be looking into using this as an astrograph (a wide-field imaging scope). I suggest the optional photographic field flattener, Stellarvue's SFF60 ($299).

Big praise

All in all, I was quite impressed with the SV60EDS. It's a sharp little telescope — both to look at and to look through. It's obvious that Stellarvue took much care and paid attention to details in the design and production of this model. If I were looking for an apochromat in this size range, this one would definitely find its way onto the short list of contenders.



The front lens of the SV60EDS is a 2.4-inch f/5.5 doublet. The company manufactures one of the lens elements from Ohara FPL–53 glass.



The one-piece aluminum clamshell ring has a Vixen-style dovetail rail underneath and a shoe for a finder scope.

PRODUCT INFORMATION

Stellarvue SV60EDS
Type: Apochromatic refractor
Focal length: 330 millimeters
Focal ratio: f/5.5
Length: 8.5 inches (216mm) (dew shield retracted, focuser in)
Weight: 2.5 pounds (1.1 kilograms) (tube only)
Included: Dual-speed 2" focuser, foam-lined carrying case, clamshell-style ring with attached Vixen-style rail
Price: $599
Contact: Stellarvue
11820 Kemper Road
Auburn, CA 95603
[t] 530.823.7796
[w] www.stellarvue.com

WorldMags.net



ASTROSKETCHING

BY ERIKA RIX

Galaxy groupings

Galaxy season has arrived! The Virgo Cluster alone provides an abundance of sketching targets, frequently with multiple systems captured in a single field of view. Rendering such groupings can be a breeze if you break the process into manageable steps. A good combo with which to build experience is NGC 5774 and NGC 5775, a contrasting pair of interacting spirals 2.5° northeast of the star 109 Virginis near the Maiden's foot.

Although both are of similar size and magnitude, you'll likely spot edge-on NGC 5775 first, along with a 13th-magnitude star 1' northeast of its midline. NGC 5774 lies 4.5' farther northwest, but due to its face-on orientation, it has a lower surface brightness and may prove difficult to see through a 6-inch telescope.

When framing the galaxies in the eyepiece for your sketch, try placing one or two prominent stars near the edge of the field of view. Doing so makes it easier to return to the exact star field when using a non-tracking mount. Plot the brightest stars first while cross-referencing their magnitudes and positions. Imagining a clock face or geometric shapes and lines connecting the stars will help with accuracy.

Once you've placed enough stars for reference, draw the first galaxy. NGC 5775 extends 4' in a northwest to southeast orientation so that, as labeled in the image at right, it crosses midway and beyond the imaginary lines connecting stars B to D and B to C. It's also nearly in alignment with the star at point A.

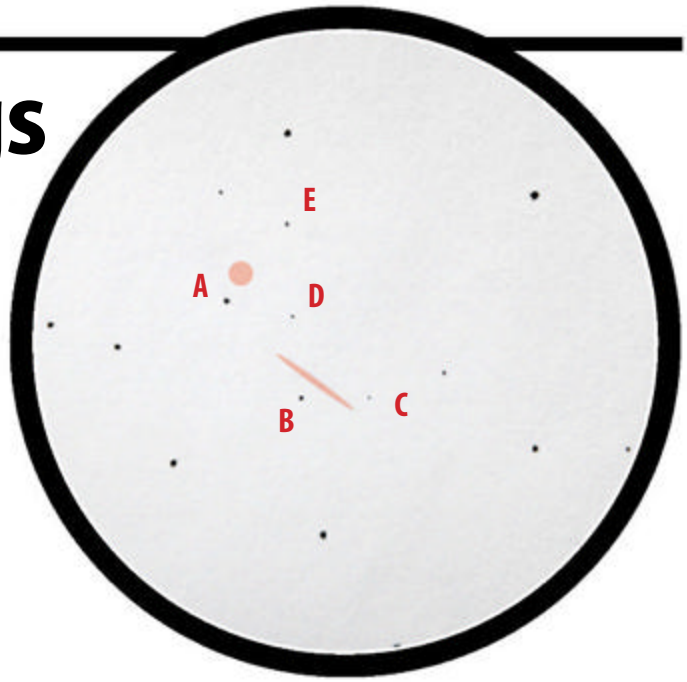
Lightly mark the galaxy's position on the sketch using an eraser shield as a straight edge. Rub the tip of a blending stump through a patch of graphite created outside the sketch circle, and then use it to draw the galaxy, adjusting its pressure as needed for brightness. If you observe an elongated, central brightness, use the eraser shield once again to draw a darker line through the galaxy. Remember, you're actually creating a negative drawing when using graphite on white paper, so dark markings represent brightness.

NGC 5774 spans 3.0' by 2.5' and appears as a faint circular glow that, when increasing the aperture to 16 inches, brightens with a soft core. If you draw an imaginary line between the stars at points A and E, the galaxy is slightly offset northwest of it.

Starting at the galaxy's center, render its faint glow with a loaded blending stump. Work your way gradually outward in a circular motion. You can adjust the stump's pressure and add more graphite for brightness as needed.

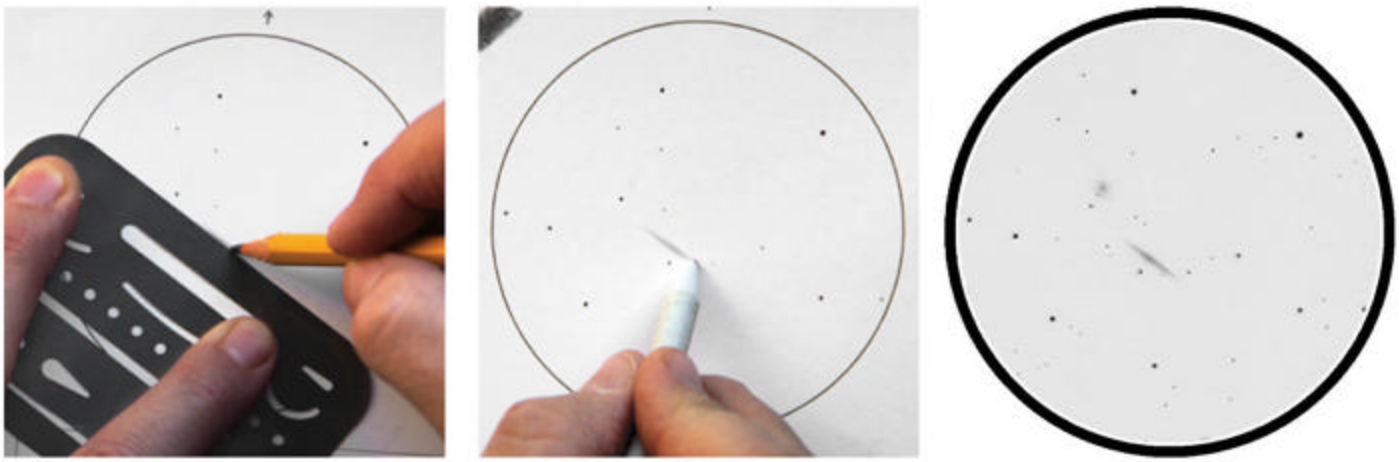
Complete the sketch by adding the remaining star field, and, if desired, use a blending stump to produce a soft glow around the brightest stars. For a challenge, try capturing spiral galaxy IC 1070 just 4' southwest of NGC 5775. At 14.4 magnitude with a 36" by 18" spread, it'll appear as a very faint smudge with averted vision.

Happy galaxy hunting!



In the first stage of her sketch of galaxies NGC 5774 and NGC 5775 in the Virgo Cluster, the author has plotted only the brightest stars to orient the field of view. She labels a few of these stars to help you envision where the galaxies will be placed. The author used a 16-inch f/4.5 reflector on a Dobsonian mount for the observations, with a 12mm eyepiece for a magnification of 150x. The author used white printer paper, a black superfine felt-tipped artist pen, a #2 pencil, and a 0.5mm mechanical pencil. The sketch is oriented so that north is to the left and west to the top.

ALL SKETCHES/PHOTOS: ERIKA RIX



The author used the edge of an eraser shield to mark the midline of NGC 5775 (left), and then used a blending stump to produce the body of the galaxy (middle). NGC 5774, additional stars, and soft glow around the brightest stars complete the sketch (right). She scanned the final version and cleaned up rough edges of stars using Photoshop.

WorldMags.net

ASTRONOMY.COM

brings the sky above to you with these great subscriber-only benefits:



You'll receive:

- **Equipment review archive** – Expert analysis of 200 + telescopes, binoculars, cameras, and more!
- **StarDome Plus** – Your personal guide for locating stars, planets, asteroids, and more!
- **Star Atlas** – 24 zoomable star charts show 45,000 stars and 800 deep-sky objects!
- **The sky this month** – Your road map to each month's observable celestial events!
- **Ask Astro** – The informative source that answers reader questions with expert explanations.
- **Multimedia gallery** – A vast collection of pictures, movies, and audio.
- **PLUS**, many more Web site extras available only to subscribers!

Visit
Astronomy.com
today!

Astronomy magazine

P21454 photo credit: ESO

ALCON 2015

July 9 - 11, 2015
Las Cruces, New Mexico
"America's Dark Sky Paradise"

Great place, great speakers, great tours, star parties and live entertainment!

ALCON2015.ASTROLEAGUE.ORG

When You Surround Yourself with

GOOD PEOPLE

Good Things Happen!



OPT

OPT is Here to Serve You!

OPTtelescopes.com | 800.483.6287

WorldMags.net



COSMIC**IMAGING**

BY ADAM BLOCK

Maximize a minimum filter

Faint to medium-bright stars in an image can be a distraction, making it difficult to appreciate a nebula or galaxy. Using a minimum or erosion filter is a wonderful way to de-emphasize star-crowded fields and thereby dramatically enhance your image.

The ideas of distraction and optical confusion play a part in our daily lives. Signage for roads and the design of stairs strive to minimize optical confusion for public safety. Thankfully, it is unlikely anyone will injure themselves while admiring your space art; but using a minimum filter can make it easier to see large extended structures seemingly hidden by the stars.

The standard method in Photoshop is to use "Color Range" to select only the bright stars in an image (see Image #1). Then follow these steps:

1. Choose "Highlights" as the selection method, and adjust the "Fuzziness" and "Range" sliders until only the stars appear in the preview window with little nebulosity.

2. After pressing "OK" and creating the selection, remove any unwanted parts with the "Lasso" tool in the "Subtract" selection mode.

3. Next, "Expand" the selection by 3–6 pixels, and then "Feather" by half the value you chose. (Feathering by half the value of a selection's expansion is an excellent rule of thumb.)

4. At this point, you can apply the "Minimum" filter using a fractional pixel value if you desire, although 1 pixel is a good choice for oversampled images. Choose the "Preserve Roundness" option, which is a most appreciated kernel filter that mitigates telltale artifacts that used to plague this tool.

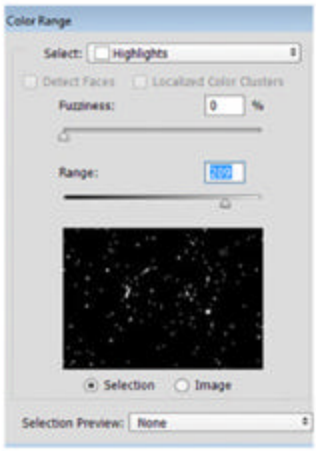


Image #1. Follow the author's method in Photoshop by first selecting the "Highlights" choice from the pull-down menu in "Color Range." Then adjust the sliders so that only stars are shown in the preview window. ALL IMAGES: ADAM BLOCK

5. This one is a secret of mine. Apply a very small "Unsharp Mask" of 2 or 3 pixels with a value of 20 to 30 percent. This will keep the stars from wilting by adding back a little brightness and a small degree of edge enhancement.

I also would like to offer a method I developed that I have not seen published elsewhere. It modifies things after step 3 above and may be a powerful tool in many situations. Make a copy of your layer, and after doing steps 1 through 3 above, try the following:

4. Select "Create New Layer Mask" by pressing the small icon at the bottom of the "Layers" palette. This will convert your selection to a slightly bloated star mask like Image #2. Remember you can always convert a selection to a mask and vice versa.

5. On the upper layer, once again choose "Color Range" ("Highlights") to select the stars that have the same settings as those you chose the first time, but this time "Contract" the selection by 1 pixel.

6. Now enter the layer mask by pressing the ALT button and clicking on it. The selection will still be visible.

7. Finally, right click on the selection, and choose "Fill." Fill the selection with black.

Your mask will look like Image #3. This is something like a contour or halo star mask. The difference between the expansion and contraction of the selection determines how large these rings are around stars. The benefit is that any modification you make to stars using this type of mask will affect most strongly the edges or halos of stars. In our particular case, we employ the minimum filter as described above and now have much greater control of the erosion process — all without clobbering the centers of stars!

In the next column, I will investigate the stories that images tell and how that informs the choices we make when processing our data.

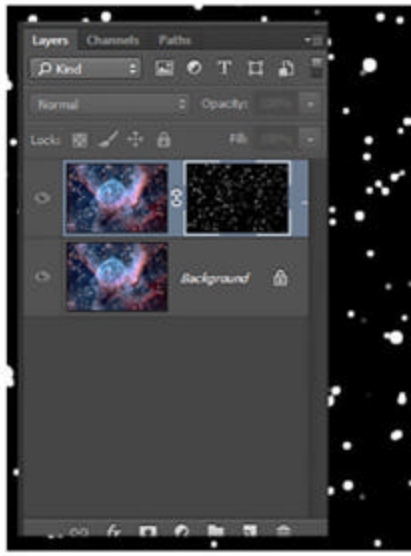


Image #2. After duplicating your image and creating the expanded selection, press the "Create New Layer Mask" button in the "Layers" palette to transform your selection into a mask. You'll find a high-resolution version of NGC 2359 at http://skycenter.arizona.edu/gallery/nebulae/ngc2359.

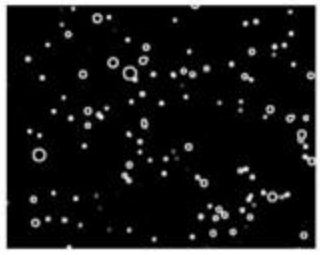


Image #3. Re-select the stars, and "Contract" the selection by 1 pixel. Then enter the star mask and "Fill" with black in the selection. This will blacken the centers of stars and leave the rings shown here. This contour star mask is a powerful tool in many applications.

FROM OUR INBOX

Alien visits

To dismiss and equate all UFO sightings ("Let's cut the UFO crap," March issue, p. 9) to an "incredible naiveté" in the belief of alien visits to Earth is a pretentious statement by Editor David J. Eicher. After all, cosmological acceptance of inflation and that all matter evolved from a point source are just as incredible. It is a wonder out there, and there remains much to be understood. It's too bad not to have more open-mindedness from the editor of this magazine. **— Barry Pfannebecker,** South Deerfield, Massachusetts

Corrections

On p. 42 in the March issue, #177 should have read "Wilhelm Röntgen." **— *Astronomy* Editors**

In our March issue (p. 56), #252 should have read, "On August 28, 2003, Mars came closer to Earth than it had in 60,000 years." The next time Mars will be closer will occur August 28, 2287. **— *Astronomy* Editors**

BROWSE THE "COSMIC IMAGING" ARCHIVE AND FIND VIDEO TUTORIALS AT **www.Astronomy.com/Block.**

WorldMags.net

March 2–11, 2016

Tour BALI and witness a TOTAL ECLIPSE

with *Astronomy* magazine



Experience a solar eclipse trip like no other in the equatorial paradise of Indonesia. Immerse yourself in the festivities leading up to the Balinese New Year before watching the Moon block the Sun's light in a total solar eclipse. Your tour includes:

- Balinese rituals that few ever witness
- Visits to stunning ancient temple gardens
- Lectures and eclipse viewing guidance from *Astronomy* staff
- And much more!

JOIN THE TRIP TODAY!

Visit www.astronomy.com/bali

Astronomy magazine

TRAVELQUEST International

P24157

William Cho (landscape); Mike Reynolds (eclipse)

Exclusive podcasts from *Astronomy* magazine

Superstars of Astronomy

Editor David J. Eicher interviews the world's top scientists!

Monthly hourlong conversations with the greatest minds in astronomy, covering cosmic beginnings, how life will end on Earth, Mars exploration, the search for extraterrestrial intelligence, and much more!



JEFF HESTER
From the Big Bang to Big Brains: Life and the Universe



GARIK ISRAELIAN
Mixing Science and the Arts at the Starmus Festival



ALAN STERN
The Journey to Pluto and Why It's Still a Planet

Astronomy magazine

LISTEN NOW AT www.Astronomy.com/superstars

Brought to you by CELESTRON

P25326

WorldMags.net

NEW PRODUCTS

Attention, manufacturers: To submit a product for this page, email **mbakich@astronomy.com**.

Motorized focuser

JMI Telescopes
Lakewood, Colorado

JMI Telescopes' MOTOFOCUS for William Optics ZenithStar 110 refractor is a battery-operated hand controller with an electric focus motor that attaches to the shaft of a focuser knob (or the knob itself). The unit is small, lightweight, and installs in seconds. The controller output is pulse-width modulated.

Price: $179
[t] 800.247.0304
[w] www.jmitelescopes.com





Truck tent

Napier Enterprises
Niagara Falls, New York

Napier's Sportz 57 Series Truck Tent assembles in the back of your open-bed pickup, creating a sleeping area for two people. Features include vents and two windows. A rear window allows you to access the truck cab from inside the tent. The model 57044 tent fits trucks with 5-foot beds, like the Chevrolet Colorado, GMC Canyon, and upcoming 2016 Ford Ranger.

Price: $269.99
[t] 800.567.2434
[w] www.napieroutdoors.com

Night sky app

United Soft Media
Munich, Germany

United Soft Media's Redshift Discover Astronomy app shows what you can see in the current night sky and takes you on a 3-D flight. Its database contains more than 100,000 stars and many solar system objects.

Price: $2.99
[t] 49.89.29088.161
[w] www.usmgames.com





21mm eyepiece

Celestron, Torrance, California

Celestron's Ultima Duo 21mm Eyepiece offers a 68°-wide apparent field of view and 20 millimeters of eye relief. It contains eight optical elements in five groups, all of which are fully multicoated. The barrel has integral 42mm T-adapter threads as well as internal threading to accept filters.

Price: $129.95
[t] 310.328.9560
[w] www.celestron.com

SEE REPORTS ON 350+ PRODUCTS AT **www.Astronomy.com/equipment.**

JOIN *ASTRONOMY* MAGAZINE'S
AURORA ADVENTURE
OCTOBER 5–15, 2015

Experience a once-in-a-lifetime northern lights tour along the Norwegian coast and interior with *Astronomy* magazine and TravelQuest International. The trip includes:

- 6 nights of dark-sky aurora viewing
- 4 days cruising Norway's fjords aboard the MS *Nordnorge*
- 3 days exploring past and present Sami culture
- Lectures and night sky viewing with *Astronomy* staff
- Guided tours by local experts
- And much more!

Astronomy magazine TRAVELQUEST international

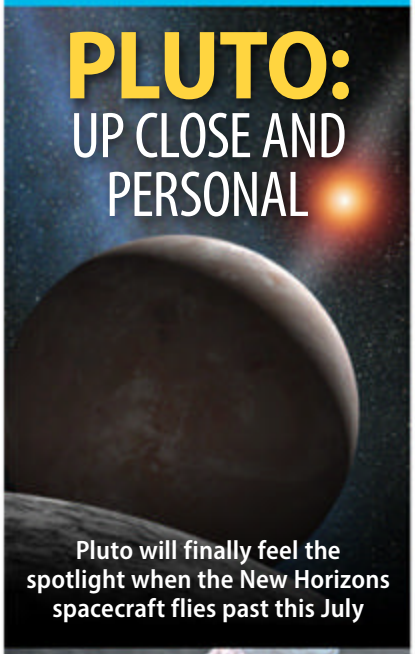


RESERVE YOUR SPOT TODAY!
Visit www.astronomy.com/norway
P23642

WorldMags.net

COMING IN OUR

NEXT ISSUE



PLUTO: UP CLOSE AND PERSONAL

Pluto will finally feel the spotlight when the New Horizons spacecraft flies past this July



Death plunge asteroids

Can we find space rocks like Chelyabinsk before they enter our atmosphere?



Get set for Asteroid Day

PLUS

- Hunt the last planet
- Set your sights on the Great Rift
- Catch some Moon rays
- The nature of observing
- Vacation with the stars
- Star Adventurer mount reviewed

Astronomy magazine

RON MILLER (PLUTO); M. BOSLOUGH/B. CARVEY/A. CARVEY (DEATH PLUNGE); METEOR CRATER (ASTEROID DAY)

Astronomy 2015 Summer Sweepstakes OFFICIAL RULES

NO PURCHASE NECESSARY TO ENTER OR CLAIM PRIZE. A PURCHASE WILL NOT INCREASE YOUR CHANCE OF WINNING. VOID WHERE PROHIBITED.

1. Eligibility. The *Astronomy* 2015 Summer Sweepstakes (the "Sweepstakes") is open to residents of the United States and Canada (except Quebec) only, who are age 18 years or older and have reached the age of majority in their state/province of residency at the time of entry. Employees (and their dependents and immediate household members) of Kalmbach Publishing Co., ("Sponsor"), and of Celestron Acquisition, LLC ("Celestron"), their advertising and promotional agencies and sponsoring companies are not eligible to participate. Void in Quebec and where prohibited by law. Sweepstakes is subject to all applicable federal, state and local laws.

2. Sweepstakes Period. The Sweepstakes begins on March 24, 2015 at 12:00:00 a.m. Central Time, and all entries must be transmitted online no later than July 24, 2015 at 11:59:59 p.m. Central Time.

3. How to Enter. To enter, complete the Sweepstakes Official Entry Form online at www.Astronomy.com/sweeps with your name, address, city, state or province, and ZIP or postal code, and then click on the SUBMIT MY ENTRY button. You may submit only one entry through the Sweepstakes Online Entry Form during the Sweepstakes Period. However, when you submit your entry online, you will receive a link that you can share on Facebook, Twitter, Google Plus or by email; you will automatically receive three additional entries for each person who enters the Sweepstakes using that link. The online entry form must be filled out completely to be eligible. This Sweepstakes is in no way sponsored, endorsed, administered by, or associated with, Facebook, Twitter or Google Plus. Entries from any person submitting more than the stated number will be disqualified.

4. Prizes/Approximate Retail Value ("ARV") in U.S. Dollars. One (1) Grand Prize consisting of a NexStar Evolution 6. (ARV of Grand Prize: $1,199.00.) One (1) First Prize consisting of a COSMOS 90GT WiFi (ARV of First Prize: $399.95). One (1) Second Prize consisting of a SkyMaster Pro 15x70 Binoculars (ARV of Second Prize: $199.95). One (1) Third Prize consisting of a COSMOS FirstScope (ARV of Second Prize: $69.95). Ten (10) Fourth Prizes consisting of a one year subscription to *Astronomy* magazine (ARV $42.95 each).

5. Drawing/Odds/Notification. A random drawing for the Grand Prize, the First Prize, the Second Prize, the Third Prize, and the Fourth prizes will be held on or around September 22, 2015. Odds of winning depend on the number of entries received. Limit one prize per person. The average total circulation for *Astronomy* magazine is 102,934. Winners will be notified by email on or before October 6, 2015.

6. Prize Restrictions. No cash equivalent or prize substitution permitted. All prizes subject to the guarantees/warranties of the manufacturer. Any applicable federal, state, and/or local taxes are the responsibility of the winner. For prizes of $600 or more in value, winner's Taxpayer I.D. will be required to issue a Form 1099-MISC showing prize ARV as income.

7. Validation and Acceptance. Winner(s) in the *Astronomy* 2015 Summer Sweepstakes will be selected in a random drawing. The potential winner(s) may be required to sign and return an Affidavit of Eligibility, publicity release, and Release of Liability within fourteen (14) days of notification. If a potential winner cannot be contacted within a reasonable time period, if the potential winner is ineligible, if any notification is undeliverable, or if the potential winner otherwise fails to fully comply with these Official Rules, he/she will forfeit that Prize, and if time permits, an alternate winner will be randomly drawn from among all remaining Sweepstakes entries. Canadian prize winners subject to skill test requirement.

8. Winners List. For a list of winners, see the *Astronomy* website (www.astronomy.com) after November 21, 2015, or send a stamped, self-addressed envelope to: *Astronomy* 2015 Summer Sweepstakes Winners List, P.O. Box 1612, Waukesha, WI 53187-1612. (Residents of FL, VT, and WA may send a self-addressed envelope without the stamp.) Requests for Winners List must be received by July 24, 2015.

9. Limitations of Liability. Sponsor and Celestron Acquisition, LLC are not responsible for and shall not be liable for: (i) telephone, electronic, hardware or software program, network, Internet, or computer malfunctions, failures, or difficulties of any kind; (ii) failed, incomplete, garbled, or delayed computer transmissions; (iii) any condition caused by events beyond the control of Sponsor that may cause the Sweepstakes to be disrupted or corrupted; (iv) any injuries, losses, or damages of any kind arising in connection with or as a result of the prize, or acceptance, possession, or use/misuse of the prize, or from participation in the Sweepstakes; (v) any printing or typographical errors in any materials associated with the Sweepstakes; (vi) any change in participant's telephone number, mailing address or email address. Sponsor reserves the right, in its sole discretion, to suspend or cancel the Sweepstakes at any time if a computer virus, bug tampering, unauthorized intervention, or other technical problem of any sort corrupts the administration, security, or proper play of the Sweepstakes. Sponsor also reserves the right to disqualify, in its sole discretion, any person tampering with the entry process, the operation of the website, or who is otherwise in violation of the rules. By participating in the Sweepstakes, each participant agrees to release and hold Sponsor, Celestron Acquisition, LLC, their employees, officers, and directors, their advertising and promotional agencies, and sponsoring companies harmless from any and all losses, damages, rights, claims and actions of any kind in connection with the Sweepstakes or resulting from acceptance, possession, or use/misuse of any prize, including without limitation, personal injury, death, and property damage, and claims based on publicity rights, defamation, or invasion of privacy.

10. Additional terms. By entering the Sweepstakes, participants agree to be bound by these official rules and all decisions of Sponsor. Except where prohibited, each entrant agrees that: (1) any and all disputes, claims and causes of action arising out of or connected with this Sweepstakes shall be resolved individually, without resort to any form of class action, and exclusively by state or federal courts situated in Wisconsin, (2) any and all claims, judgments and awards shall be limited to actual out-of-pocket costs incurred, but in no event attorneys' fees, (3) no punitive, incidental, special, consequential or other damages, including, without limitation, lost profits, may be awarded (collectively, "special damages"), and (4) entrant hereby waives all rights to claim special damages and all rights to such damages multiplied or increased. Wisconsin law, without reference to choice of law rules, governs the Sweepstakes and all aspects related thereto.

11. Sponsor. Sponsored by Kalmbach Publishing Co., P.O. Box 1612, Waukesha, WI 53187-1612.

P25#78

WorldMags.net

Khan Scope Centre

"The Astronomy shop with a Difference!"

©www.khanscope.com

Far West Texas Ranch For Sale

Home +/- 7240 Acres River Front Canyon Land

Newly renovated & fully furnished. Dark Skies, various observation points. $2,715,000.

For more information:

www.landsofamerica.com/member/53998

or call Lenk Real Estate 713-385-3801

THE NINE PLANETS RING

HANDCRAFTED WITH AN ORBITING GIBEON METEORITE BAND IN 18K GOLD SET WITH 9 GEMSTONES

JEWELRYDESIGNSFORMEN.COM

831.336.1020

Optical Coatings
Parabolic Mirrors
Testing
Refiguring

www.OpticWaveLabs.com

Shelyak INSTRUMENTS

LISA Pack

Spectroscopy made easy...

www.SHELYAK.com

See the Universe in color live with

MALLINCAM

Astronomical Video CCD Cameras

MALLINCAM.COM

Howie Glatter's Laser Collimators & Accessories

tuBlug ™ and Blug™ Barlowed collimation aids

- SkyPointers™ & brackets
- Glatter Mirror Sling kits

SEE US AT NEAF

The Parallizer™

2"-1.25" adapter for Perfect Parallel Alignment

Howie Glatter 3850 Sedgwick Ave. Bronx, N.Y. 10463

Tel/Fax (718) 796 3203

www.skypointer.net www.collimator.com

e-mail: howieglatter@mindspring.com

HOME-DOME AND PRO-DOME OBSERVATORIES

PROFESSIONAL DESIGN - AMATEUR PRICE

★ 6, 10, & 15 ft. Diameter
★ Stand-alone or On Building
★ All Fiberglass
★ Easy Assembly
★ Manual/Computer Automated
★ Full Height/Handicap Access
★ Priced from $3,295

CloudWatcher

Low cost, accurate system to detect cloud cover, light levels and first traces of rain. With DDW interface.

www.clouddetection.com

Call or write for FREE Brochure

TECHNICAL INNOVATIONS

Phone: 407-601-1975 • www.homedome.com

all sky cam

Day and night
View from anywhere
360° horizon to horizon

660-675-5066

www.MoonglowTech.com

ECLIPSE SHADES™

Safe Solar Viewers

CE Certified

SAFE FOR DIRECT SOLAR VIEWING

Rainbow Symphony, Inc.

818-708-8400 • Fax 818-708-8470

www.rainbowsymphony.com

TAKE IT ANYWHERE!

STELLARVUE
SV60EDS
60 mm f-5.5
Apochromat

STELLARVUE®

SEEING IS BELIEVING

WWW.STELLARVUE.COM

11820 KEMPER ROAD
AUBURN, CALIFORNIA 95603
(530) 823-7796

StarGPS

"Plug & Play" GPS for Vixen Starbook, AP-GTO, Meade, Celestron, Gemini

www.stargps.ca

www.Vernonscope.com

BRANDON EYEPIECES

- 6-48mm focal length
- Ultrasharp
- Superior contrast
- American made

vernonscope@gmail.com

FOCUS ON

The Sierra Nevada Observatory, OSN
Loma de Dilar, Sierra Nevada Mt. Range
Province of Granada, Spain

The observatory is located at nearly 3000 meters and is operated by The Institute of Astrophysics of Andalucia. The Ash-Domes house two Ritchey-Chretien telescopes, 1.5 and 0.9 meter. A separate building houses a 0.6m telescope. The observatory is used exclusively for research in many areas of Astrophysics.

http://www.osn.iaa.es/osn_eng.html

ASH MANUFACTURING COMPANY
P.O. Box 312
Plainfield, IL USA 60544
815.436.9403 • FAX 815.436.1032
web site: **www.ashdome.com**
email: **ashdome@ameritech.net**

Major astronomical groups, amateurs, universities, colleges, secondary & primary schools recognize **ASH-DOME** internationally for their performance durability and dependability. Standard sizes from 8 to 30 feet in diameter. Brochures and specifications available.

WorldMags.net

REWARD

$5,000.00

will be paid to the first person to disprove "The AP Theory"

the formation of water and our solar system

CONTEST RULES

1. One theory cannot be used to disprove another theory
2. All facts must be verified by an encyclopedia
3. Must include successful experiments and specific details
4. One example in nature must be submitted

Theory: www.aptheory.info

Comments: aptheory@aptheory.info

no purchase necessary

ScopeStuff

Telescope Accessories & Hardware

World's largest inventory of telescope accessories, adapters and hardware. Free shipping in the USA!

www.scopestuff.com

512-259-9778



Build Your Own

Custom Astronomical Adapter

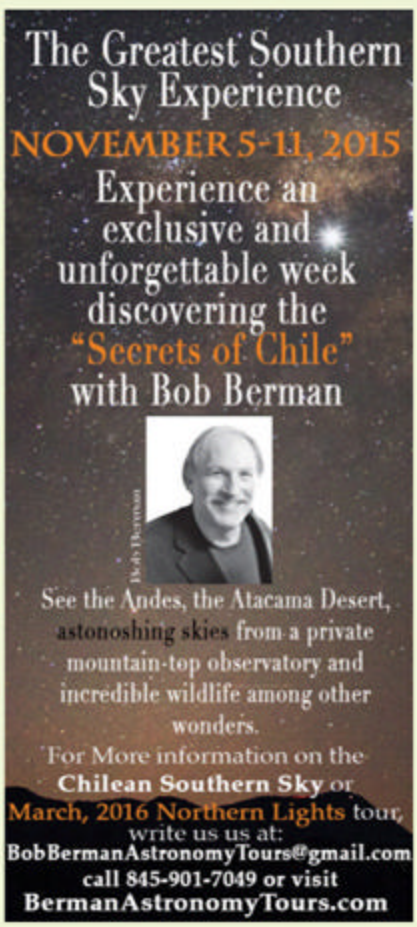
www.preciseparts.com

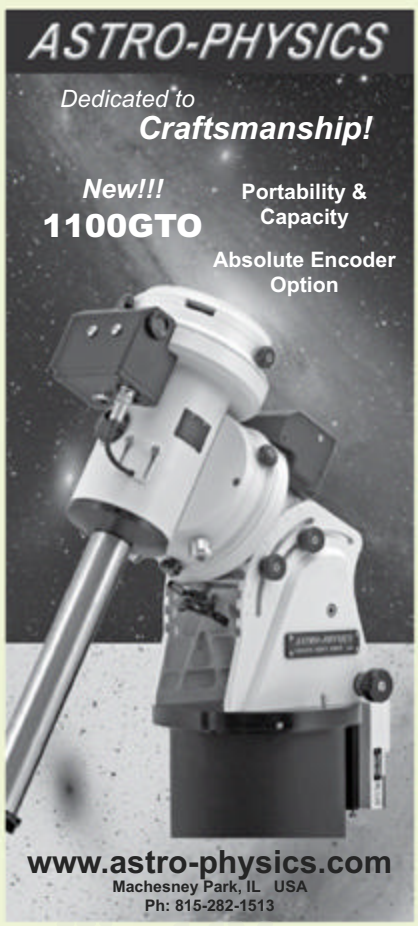
+1 305 253-5707

info@preciseparts.com

PRECISEPARTS







INDEX *of* ADVERTISERS

Adorama 17
ALCon 2015 65
AP Theory 71
Ascent/Sotheby's International Realty .. 17
Ash Manufacturing 70
Astro Haven 71
Astro-Physics 71
Astrodon 22
Astronomy Sweepstakes 19, 69
Astronomy Travel Tours 67, 68
Astronomy.com 65
Bob Berman Tours 71
Celestron 2, 76
Discover magazine 8
Glatter, Howard 70
iOptron 17
ISTAR Optical 71
Jewelry Designs for Men 70
Khan Scope Centre 70
Kitt Peak National Observatory 23
MallinCam 70
Moonglow Technologies 70
Mr. Starguy - Vixen Optics 23
Now You Know Media 7
Oberwerk 22
Oceanside Photo & Telescope 65
Optic Wave Laboratories 70
Orion Telescopes & Binoculars 5
Precise Parts 71
Rainbow Symphony 70
Sandra Haddock 70
ScopeStuff 71
Shelyak Instruments 70
Simulation Curriculum Corp. 22
SkyWatcher - USA 75
StarGPS 70
Stellarvue 70
Superstars of Astronomy 67
Technical Innovations 70
Tele Vue Optics, Inc. 23
Vernonscope LLC 70
Woodland Hills Cameras & Telescope ... 15
World Science Festival 3

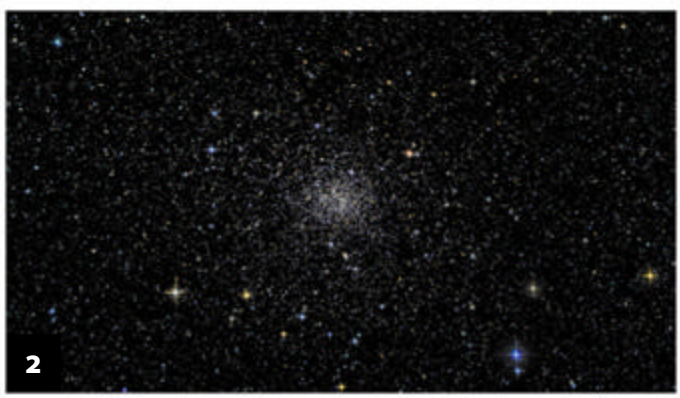
The Advertiser Index is provided as a service to *Astronomy* magazine readers. The magazine is not responsible for omissions or for typographical errors in names or page numbers.

WorldMags.net

READER GALLERY



1. LOOP DE LOOP
This composite image combines 28 exposures of Venus from November 2013 to March 2014. Of those, the first 16 show the planet in the evening sky and the last 12 catch it in the morning sky. (Venus: Canon EOS 5D Mark II DSLR, 50mm f/1.8 lens set between f/2.8 and f/3.5, ISO 400 generally, but also ISO 200 and ISO 800 on occasion; background sky: Canon EOS 6D DSLR, 50mm f/1.8 lens set at f/3.2, ISO 800) • ***Tunç Tezel***



2. AGE DISCRIMINATION
Open cluster NGC 6791 in Lyra ranks as one of the oldest of these objects. Recent studies date some of its stars to 8 billion years old. (8-inch Explore Scientific PN 208/3.9 Newtonian Astrograph at f/4.1, Canon XSi DSLR, ISO 800, thirty-seven 5-minute exposures, stacked) • ***Chuck Kimball***

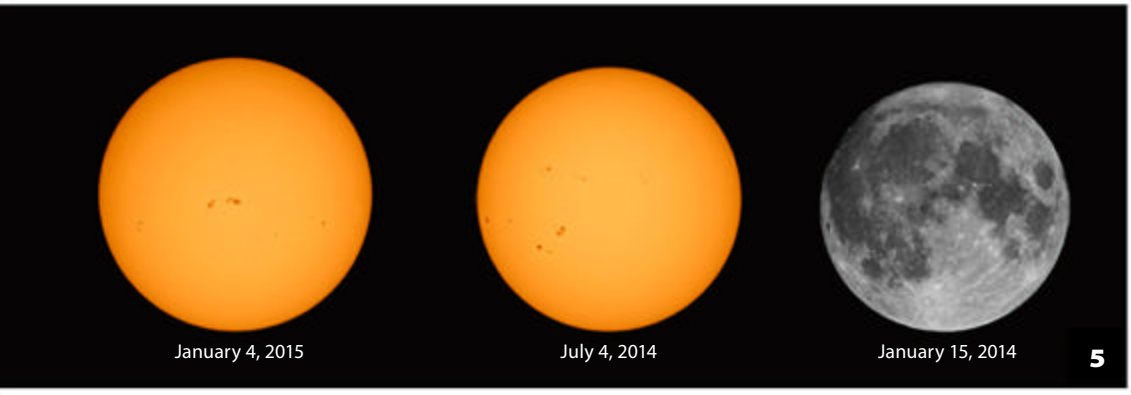


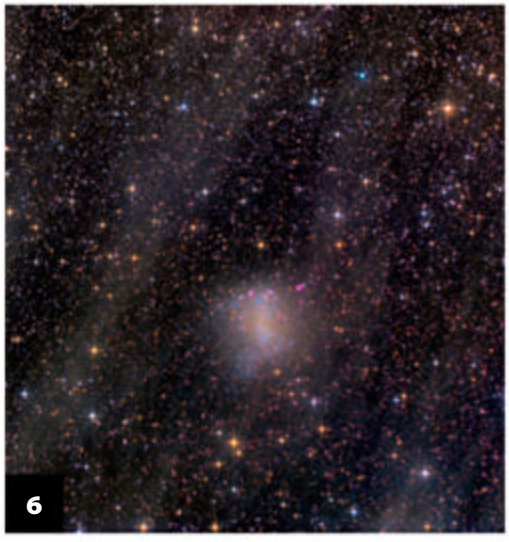
3. CRUISING THE DEEP SKY
Comet Lovejoy (C/2014 Q2) passed near globular cluster M79 in December. Look closely to see the galaxy NGC 1886 immersed in the coma. (4-inch Takahashi FSQ-106ED refractor, SBIG STL-11000M CCD camera, LRGB image with exposures of 3, 1, 1, and 1 hour, respectively, taken December 29, 2014, remotely from Siding Spring, Australia) • ***José J. Chambó***



WorldMags.net









4. DID YOU SAY "BRIGHT"?
Lynds Bright Nebula 1122 is a cloud of dust located in the constellation Libra the Scales. Beverly T. Lynds, the creator of a catalog of similar objects, rated this one at a 4 out of 6 (with 6 being the dimmest) on her brightness scale. (3.6-inch Astro-Tech AT90EDT refractor at f/6.7, SBIG ST-8300M CCD camera, LRGB image with exposures of 120, 40, 40, and 40 minutes, respectively) • ***Dan Crowson***

5. NEAR AND FAR
This set documents the changing sizes of the Sun and the Full Moon during a one-year span. From left to right, they represent the Full Moon nearest perigee, when the Moon's apparent diameter was 33.81'; perihelion, when the Sun's diameter was 32.55'; aphelion (31.48'); and the Full Moon nearest apogee (29.72'). (8-inch Sky-Watcher Newtonian reflector, Canon 40D DSLR, each image is a stack of 30 frames, taken from Kerman, Iran) • ***Ehsan Rostamizadeh***

6. GALAXY THROUGH GAS
Barnard's Galaxy (NGC 6822) lies 1.6 million light-years away in Sagittarius. Between it and us, however, is the Integrated Flux Nebula, gas and dust illuminated by the combined energy of the Milky Way's stars. Also, the blue disk to the upper right is the planetary nebula called the Little Gem (NGC 6818). (16-inch Dream Telescopes Astrograph at f/3.75, Apogee Alta U16M CCD camera, LRGB image with exposures of 60, 6, 6, and 6 minutes, respectively) • ***Kfir Simon***

7. DUSTY BEARD
NGC 1788 is a reflection nebula in Orion with some red emission nebulae. But the main object is the intensely blue region at center and the dusty swath running to the bottom of the image. (14.5-inch RC Optical Systems Ritchey-Chrétien telescope, Apogee U16M CCD camera, LRGB image with exposures of 300, 260, 160, and 260 minutes, respectively) • ***Mark Hanson***

Send your images to:
Astronomy Reader Gallery, P. O. Box 1612, Waukesha, WI 53187. Please include the date and location of the image and complete photo data: telescope, camera, filters, and exposures. Submit images by email to readergallery@astronomy.com.

WorldMags.net

BREAK THROUGH

A stunning VISTA view

Amateur astronomers know the Trifid Nebula (M20) in Sagittarius well. At visible wavelengths, dark dust lanes divide the bright star-forming region into three distinct parts. But this infrared image shows the Trifid in a different light. Captured with the 4.1-meter Visible and Infrared Survey Telescope for Astronomy (VISTA) at Paranal Observatory in Chile, M20 glows a ghostly blue (bottom) while more distant objects shine through. Astronomers also discovered two Cepheid variable stars in this wide-field view. The Trifid lies about 5,200 light-years from Earth, while the Cepheids are 37,000 light-years distant, some 10,000 light-years beyond the galaxy's center. ESO/VVV CONSORTIUM/D. MINNITI



WorldMags.net

MORE DOBS. MORE VALUE.

AT SKY-WATCHER USA WE'RE EXPANDING OUR LINE OF AWARD-WINNING DOBSONIANS. THAT MEANS MORE MODELS, MORE FEATURES, MORE VALUE FOR YOU.

When you want the most bang for your buck astronomically there's only one way to go: Dobsonians. There's a reason these things are called light buckets, there's no other OTA design out there that's going to give you the same dollar to aperture ratio. And since, here at Sky-Watcher USA, we're all about delivering value, we've expanded our line of award-winning Dobsonians.

Traditional Dobsonians
If you're looking for a no-frills telescope designed to deliver the maximum amount of light for the least amount of money, this is it. The Traditional series is a streamlined and easy-to-use approach to astronomy. All models include a rack-and-pinion focuser, finderscope and two eyepieces.

Collapsible Dobsonians
The elegant truss tube design was carefully engineered to combine ease of use, extreme portability and consistent performance in an affordable package. Unlike other truss tube designs, the Sky-Watcher Collapsible Dobsonian does not need to be disassembled between uses. It transports as two compact pieces that can be assembled and ready to use in just seconds! It is easy to collimate once set up, and it holds its collimation throughout the evening! The patented Tension Control Handle allows users to add or reduce tension, thereby increasing or decreasing the friction between the optical tube and the sideboards.

SynScan GoTo Dobsonians
The exciting Sky-Watcher Dobsonian SynScan series is precision engineered instrument that will allow you to easily find and enjoy viewing night sky treasures, such as Planets, Nebulae, Star Clusters, Galaxies and much more. With its patented collapsible tube design, these Dobsonians are truly the ultimate in portability and performance.

With apertures ranging from the ultra-portable 6-inch up to the monster light-gathering 16-inch model, all of these scopes feature Sky-Watcher's breath-taking optics and come complete with Crayford-style focuser, two Super Plössl eyepieces and finderscope.

So if you're looking for a big light bucket with a little price tag, just go to **skywatcherusa.com** or visit one of our authorized dealers for complete specifications and details.



Traditional Dobsonians

6"$305
8"$355
10"$585



Collapsible Dobsonians

8"$449
10"$699
12"$1,049
14"$1,649
16"$2,199



GoTo Collapsible Dobsonians

8"$1,035
10"$1,335
12"$2,105
14"$2,755
16"$3,655

©2015 Sky-Watcher USA. Specifications subject to change without notice. 20-15010.
Keep your eyes peeled. We're going to be rolling out more new stuff over the next few months!

Sky-Watcher® USA
Be amazed.

For information on all of our products and services, or to find an authorized Sky-Watcher USA dealer near you, just visit **www.skywatcherusa.com**.
Don't forget to follow us on Facebook and Twitter!

WorldMags.net

CELESTRON







Jupiter & Mars SKYRIS 132M
Image Credit: Christopher Go

FAST, SENSITIVE, AFFORDABLE

CMOS imaging sensors have revolutionized solar system imaging. Capture your own stunning images of the Sun, Moon, and planets with Celestron's new Skyris 132 cameras. Designed in Germany by *The Imaging Source* in collaboration with Celestron engineers in California, Skyris 132 uses the acclaimed Aptina AR0132 CMOS imaging sensor, a favorite among the world's top imagers. You'll also get a full software suite that analyzes every frame of video, throws away the ones affected by atmospheric turbulence, and precisely aligns the best frames for razor-sharp astroimages.

Skyris 132

+ The only cameras that combine SuperSpeed USB 3.0 technology with the Aptina AR0132 sensor.
+ Capture up to 200 frames per second when subframed on the planets
+ Image the full 1.2 megapixel 1/3-inch sensor at 60 frames per second, perfect for solar and lunar imaging
+ Available in color (Skyris 132C) and monochrome (Skyris 132M)



SKYRIS 132M
Attached to NexStar Evolution 8

powered by
THE IMAGINGSOURCE
ASTRONOMY CAMERAS

CELESTRON PREMIER SELECT DEALERS

OPT Telescopes – 800.483.6287 – www.opttelescopes.com
B&H Photo – 800.947.9970 – www.bhphotovideo.com
Hands On Optics – 866.726.7371 – www.handsonoptics.com
Astronomics – 800.422.7876 – www.astronomics.com
Adorama – 800.223.2500 – www.adorama.com
High Point Scientific – 800.266.9590 – www.highpointscientific.com
Optics Planet – 800.504.5897 – www.opticsplanet.com
Focus Camera – 800.221.0828 – www.focuscamera.com
Woodland Hills – 888.427.8766 – www.telescopes.net

DISCOVER MORE AT
celestron.com

WorldMags.net

MARTIN GEORGE describes the solar system's changing landscape as it appears in Earth's southern sky.

August 2015: Planets gather in evening

August begins with three bright planets hanging low in the western sky during evening twilight. Venus, Jupiter, and Mercury team up with the 1st-magnitude star Regulus to create a fine binocular scene, but don't procrastinate — the vista won't last long.

Venus is the highest and brightest of this group. It stands at an altitude of 15° a half-hour after sunset and shines brilliantly at magnitude –4.4. The planet proves to be a captivating sight when viewed through a telescope. It appears more than 50" across and sports a razor-thin crescent just 7 percent lit. The planet's large size makes the crescent easy to see even under the adverse seeing conditions typical at low altitudes.

Venus disappears into the twilight glow during August's second week as it prepares to pass between the Sun and Earth. (This so-called inferior conjunction occurs on the 15th.) But the planet returns to view before dawn barely a week later. By the 31st, you can find it about 10° above the eastern horizon 30 minutes before sunrise. A telescope then shows Venus looking remarkably similar to the way it did at the beginning of the month.

Jupiter behaves in much the same way as Venus does during August, but the outer planet moves at a slower pace. On the 1st, you can find Jupiter 6° to Venus' lower right. Shining at magnitude –1.7, the giant world appears prominent despite glowing less than 10 percent as bright as its neighbor. Unfortunately, poor seeing conditions near the horizon mean a telescope won't show much detail on the planet's 31"-diameter disk.

The gas giant world appears 2° below Regulus on August 1. As the gap between these two objects closes during the following week, **Mercury** joins the group. Pay particular attention from around August 5 to 7, when the three objects appear within 2° of one another and Venus lies some 5° to their left. For the best views, use binoculars and observe from a site with an unobstructed view of the western horizon.

Jupiter becomes lost in twilight within another week, passing on the far side of the Sun from our viewpoint August 26. Meanwhile, Mercury climbs higher in the evening sky. Although the innermost planet won't reach the peak of its apparition until early September, it becomes the most conspicuous object in the western sky by late August. On the 31st, Mercury shines at magnitude 0.1 and appears nearly 15° high a full hour after sunset. You can find it among the background stars of Virgo, some 20° below that constellation's brightest star, 1st-magnitude Spica. When viewed through a telescope on August's final evening, Mercury appears 7" across and slightly more than half-lit.

Wait for darkness to fall before targeting the solar system's most beautiful planet. **Saturn** then lies high in the northwest and in perfect position for viewing with your naked eye, binoculars, or a telescope. The ringed planet shines at magnitude 0.5 against the backdrop of eastern Libra, not far from the brighter stars of northern Scorpius. Saturn lies about 5° from both Beta (β) and Delta (δ) Scorpii, a pair of 2nd-magnitude suns in the Scorpion's head.

The planet's high altitude in early evening should translate into splendid views through a telescope. Saturn displays a disk that measures 17" across the equator surrounded by a ring system that spans 38" and tilts 24° to our line of sight. The planet's shadow appears as a dark wedge falling on the rings behind the planet just off the disk's eastern limb. Also keep an eye out for 8th-magnitude Titan, Saturn's biggest moon and the second largest in the solar system.

You might catch your first glimpse of **Mars** in late August as it begins a nearly two-year apparition. The magnitude 1.8 Red Planet hangs just 5° high in the east-northeast 30 minutes before sunrise. Search for it through binoculars some 10° to Venus' lower left.

The starry sky

One night in July 1778, French astronomer Charles Messier discovered a fuzzy patch of light in the constellation Sagittarius. He described it as a "very faint nebula … [that] contains no star. Messier did not realize he was viewing a distant globular cluster, which his telescope could not resolve into individual stars.

We now know that M54 does not even belong to our galaxy. In 1994, astronomers discovered the Sagittarius Dwarf Spheroidal Galaxy and soon realized that M54 formed a major part of it. This galaxy is far smaller than the Milky Way and already has started to collide with our own. The globular cluster currently lies about 86,000 light-years from Earth.

M54 lies among the stars of Sagittarius' prominent Teapot asterism, a region that rides high in the eastern sky after darkness falls these August evenings. The cluster stands some 1.5° west-southwest of magnitude 2.6 Zeta (ζ) Sagittarii. M54 glows at 8th magnitude and shows up through 7x50 binoculars. If you can't find it through a telescope right away, center magnitude 3.6 Gamma (γ) Sgr in your field. Then, enjoy the naked-eye and binocular view of the winter Milky Way for precisely 49 minutes. At the end of the wait, M54 will be centered in the field of view.

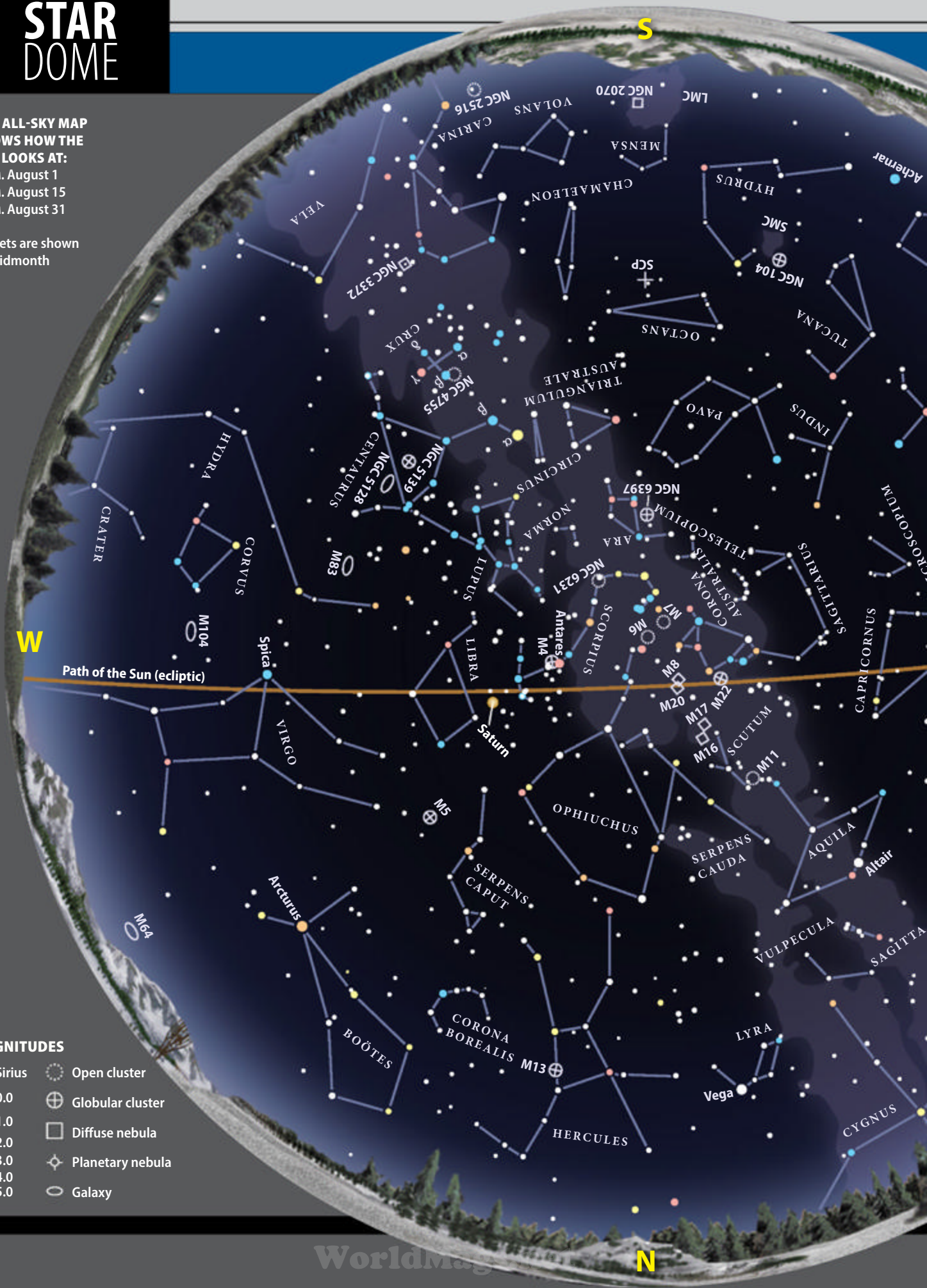
Once you've found the globular, you'll understand why Messier could not resolve it. You'll likely need a 10-inch or larger scope to see even a hint of granulation. Still, it's a thrill to view an object that belongs to another galaxy.

Just last year, astronomers looked at the abundance of lithium-7 in M54. Our galaxy has a puzzlingly low amount of this element, and some researchers suggested that this scarcity applied only to the Milky Way. But studies of the stars in M54 seem to show that this is not the case. Scientists now think that the lithium shortfall may exist throughout the cosmos.

STAR DOME

THE ALL-SKY MAP SHOWS HOW THE SKY LOOKS AT:
9 P.M. August 1
8 P.M. August 15
7 P.M. August 31

Planets are shown at midmonth



MAGNITUDES

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0

- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

WorldMag



HOW TO USE THIS MAP: This map portrays the sky as seen near 30° south latitude. Located inside the border are the four directions: north, south, east, and west. To find stars, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

STAR COLORS: Stars' true colors depend on surface temperature. Hot stars glow blue; slightly cooler ones, white; intermediate stars (like the Sun), yellow; followed by orange and, ultimately, red. Fainter stars can't excite our eyes' color receptors, and so appear white without optical aid.

Illustrations by *Astronomy*: Roen Kelly

AUGUST 2015

Calendar of events

2 The Moon is at perigee (362,139 kilometers from Earth), 10h03m UT

The Moon passes 3° north of Neptune, 15h UT

Saturn is stationary, 20h UT

5 The Moon passes 1.0° south of Uranus, 9h UT

Mercury passes 8° north of Venus, 9h UT

7 Last Quarter Moon occurs at 2h03m UT

Mercury passes 0.6° north of Jupiter, 4h UT

Mercury passes 1.0° north of Regulus, 15h UT

8 Asteroid Pallas is stationary, 12h UT

9 The Moon passes 0.7° north of Aldebaran, 0h UT

10 Jupiter passes 0.4° north of Regulus, 23h UT

13 The Moon passes 6° south of Mars, 5h UT

14 New Moon occurs at 14h53m UT

15 Asteroid Lutetia is at opposition, 14h UT

Venus is in inferior conjunction, 19h UT

16 Asteroid Vesta is stationary, 6h UT

The Moon passes 2° south of Mercury, 15h UT

18 The Moon is at apogee (405,848 kilometers from Earth), 2h33m UT

22 The Moon passes 3° north of Saturn, 17h UT

First Quarter Moon occurs at 19h31m UT

26 Jupiter is in conjunction with the Sun, 22h UT

29 Venus passes 9° south of Mars, 5h UT

Full Moon occurs at 18h35m UT

30 The Moon passes 3° north of Neptune, 0h UT

The Moon is at perigee (358,290 kilometers from Earth), 15h21m UT

See tonight's sky in Astronomy.com's STARDOME

Astronomy magazine

BEGINNERS: WATCH A VIDEO ABOUT HOW TO READ A STAR CHART AT **www.Astronomy.com/starchart.**

REGISTERED USERS GET EXCLUSIVE ACCESS!

Enjoy MORE from *Astronomy* when you register online!

- Get a weekly email newsletter featuring astronomy news, reader gallery, and sky events.
- Submit your photos and be inspired by readers' images.
- Watch exclusive videos on observing, new discoveries, cutting-edge science, and more.
- Comment on articles and share your thoughts.



FREE Gift! Register now and you'll get a collection of *Astronomy* articles to download instantly!

It's FREE to sign up! Visit Astronomy.com/Join

COMPELLING SCIENCE for curious minds.

10 issues JUST $19.95

Newton's apple. Edison's lightbulb. Hawking's astrophysics. Look where curiosity can lead you.

Connect today with the greatest ideas and minds in science.



Subscribe to *Discover* magazine and see where your curiosity takes you.

Go to **DiscoverMagazine.com**

or call **800-829-9132**

Available in print or digital format.

P25360